INTERNATIONAL LIBRARY OF TECHNOLOGY

A SERIES OF TEXTBOOKS FOR PERSONS ENGAGED IN THE ENGINEERING PROFESSIONS AND TRADES OR FOR THOSE WHO DESIRE INFORMATION CONCERNING THEM. FULLY ILLUSTRATED AND CONTAINING NUMEROUS PRACTICAL EXAMPLES AND THEIR SOLUTIONS

GEOMETRICAL DRAWING
FREEHAND DRAWING
ELEMENTS OF PERSPECTIVE
PERSPECTIVE DRAWING
HISTORIC ORNAMENTAL DRAWING
ARCHITECTURAL DRAWING
ADVANCED ARCHITECTURAL DRAWING

SCRANTON:
INTERNATIONAL TEXTBOOK COMPANY
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PREFACE

The International Library of Technology is the outgrowth of a large and increasing demand that has arisen for the Reference Libraries of the International Correspondence Schools on the part of those who are not students of the Schools. As the volumes composing this Library are all printed from the same plates used in printing the Reference Libraries above mentioned, a few words are necessary regarding the scope and purpose of the instruction imparted to the students of—and the class of students taught by—these Schools, in order to afford a clear understanding of their salient and unique features.

The only requirement for admission to any of the courses offered by the International Correspondence Schools, is that the applicant shall be able to read the English language and to write it sufficiently well to make his written answers to the questions asked him intelligible. Each course is complete in itself, and no textbooks are required other than those prepared by the Schools for the particular course selected. The students themselves are from every class, trade, and profession and from every country; they are, almost without exception, busily engaged in some vocation, and can spare but little time for study, and that usually outside of their regular working hours. The information desired is such as can be immediately applied in practice, so that the student may be enabled to exchange his present vocation for a more congenial one, or to rise to a higher level in the one he now pursues. Furthermore, he wishes to obtain a good working knowledge of the subjects treated in the shortest time and in the most direct manner possible.

In meeting these requirements, we have produced a set of books that in many respects, and particularly in the general plan followed, are absolutely unique. In the majority of subjects treated the knowledge of mathematics required is limited to the simplest principles of arithmetic and mensuration, and in no case is any greater knowledge of mathematics needed than the simplest elementary principles of algebra, geometry, and trigonometry, with a thorough, practical acquaintance with the use of the logarithmic table. To effect this result, derivations of rules and formulas are omitted, but thorough and complete instructions are given regarding how, when, and under what circumstances any particular rule, formula, or process should be applied; and whenever possible one or more examples, such as would be likely to arise in actual practice—together with their solutions—are given to illustrate and explain its application.

In preparing these textbooks, it has been our constant endeavor to view the matter from the student's standpoint, and to try and anticipate everything that would cause him trouble. The utmost pains have been taken to avoid and correct any and all ambiguous expressions—both those due to faulty rhetoric and those due to insufficiency of statement or explanation. As the best way to make a statement, explanation, or description clear is to give a picture or a diagram in connection with it, illustrations have been used almost without limit. The illustrations have in all cases been adapted to the requirements of the text, and projections and sections or outline, partially shaded, or full-shaded perspectives have been used, according to which will best produce the desired results. Half-tones have been used rather sparingly, except in those cases where the general effect is desired rather than the actual details.

It is obvious that books prepared along the lines mentioned must not only be clear and concise beyond anything heretofore attempted, but they must also possess unequaled value for reference purposes. They not only give the maximum of information in a minimum space, but this information is so ingeniously arranged and correlated, and the

indexes are so full and complete, that it can at once be made available to the reader. The numerous examples and explanatory remarks, together with the absence of long demonstrations and abstruse mathematical calculations, are of great assistance in helping one to select the proper formula, method, or process and in teaching him how and when it should be used.

Four of the volumes composing this library are devoted to the subject of architectural and decorative design. Special attention has been given to the arrangement of the subjects in a naturally consecutive order, so that the fundamental principles underlying the advanced subjects may be thoroughly understood before the broader and freer subjects depending on the taste of each individual are considered. This volume, the first of the series, is devoted to the subjects of Geometrical, Freehand, Perspective, and Architectural Drawing, which are treated purely from the mechanical standpoint of making accurate scale sketches and working drawings according to accepted practice. The mathematical precision required to make an accurate drawing for any purpose, is herein treated on the principle that the freest and most broadly artistic rendering is at all times built on a skeleton, or framework, of accurate proportions, and the student must understand the mathematical principles by which these proportions can be determined before he can take up the subject of rendering in any medium the light and shade values that go to make the drawing pictorial.

The method of numbering the pages, cuts, articles, etc. is such that each subject or part is complete in itself; hence, to make the index intelligible, it was necessary to give each subject or part a number. This number is placed at the top of each page, on the headline, opposite the page number; and to distinguish it from the page number it is preceded by the printer's section mark (§). Consequently, a reference such as § 16, page 26, will be readily found by looking along the inside edges of the headlines until § 16 is found, and then through § 16 until page 26 is found.

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CONTENTS

GEOMETRICAL DRAWING.

INSTRUMENTS AND MATERIALS.

1. A **drawing** is a representation of objects on a plane surface by means of lines or lines and shades. When done by the use of free hand only, it is called **freehand drawing** or **sketching**; when instruments are used, so that greater exactness may be obtained, it is called **instrumental,** or **mechanical, drawing.**

2. All of the instruments and materials required for the courses in drawing are mentioned in the following descriptions:

The **drawing board** should be made of well-seasoned, straight-grained pine, the grain running lengthwise. For this course, the student will need a board of the following dimensions: length over all, $22\frac{1}{2}$ inches; width, $16\frac{1}{2}$ inches.

The drawing board illustrated in Fig. 1 is the one furnished in our students' drawing outfits and can be fully recommended as possessing the qualities a good and accurate board should have. It is made of several pieces of pine wood glued together to the required width of the board. A pair of hardwood cleats is screwed to the back of the board, the screws passing through the cleats in oblong slots with iron bushings, which allow the screws to move freely when drawn by the contraction and expansion of the board. Grooves are cut through half the thickness of the board over the entire back side. These grooves take the transverse resistance out of

the wood and allow it to be controlled by the cleats, at the same time leaving the longitudinal strength nearly unimpaired. In order to provide a perfectly smooth working

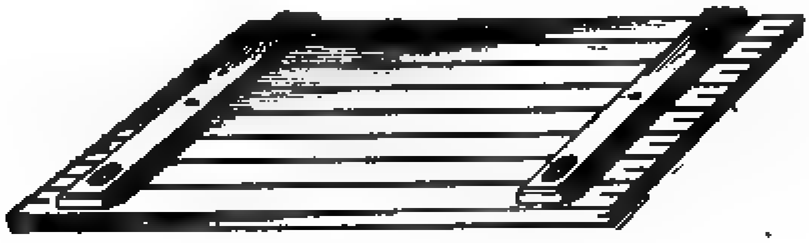

FIG. 1.

edge, for the head of the T square to slide against, a strip of hard wood is let into the short edges of the board, and is sawed through in several places, in order to allow for the contraction and expansion of the board. The cleats also raise the board from the table, thus making it easier to

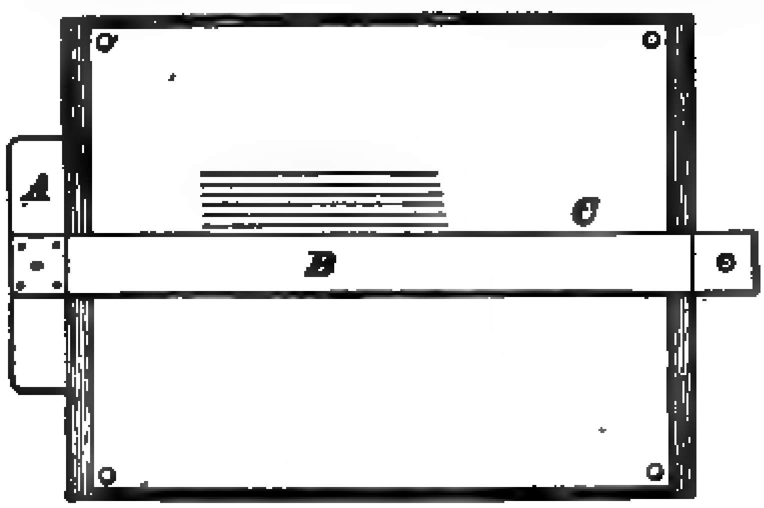

FIG. 2.

change the position of the board. When in use the board is placed so that one of the short edges is at the left of the draftsman, as shown in Fig. 2.

3. The **T square** is used for drawing horizontal straight lines. The head A is placed against the left-hand edge of the board, as shown in Fig. 2. The upper edge C of the blade B is brought very near to the point through which it is desired to pass a line, so that the straight edge C of the blade may be used as a guide for the pen or pencil. It is evident that all lines drawn in this manner will be parallel.

Vertical lines are drawn by means of triangles. The triangles most generally used are shown in Figs. 3 and 4, each of which has one right angle. The triangle shown in Fig. 3

FIG. 3. FIG. 4.

has two angles of 45° each, and that in Fig. 4 one of 60° and one of 30°. They are called *45°* and *60° triangles*, respectively. To draw a vertical line, place the T square in position to draw a horizontal line, and lay the triangle against it, so as to form a right angle. Hold both T square and triangle lightly with the left hand, so as to keep them from slipping, and draw the line with the pen or pencil held in the right hand, and against the edge of the triangle. Fig. 5 shows the triangles and T square in position.

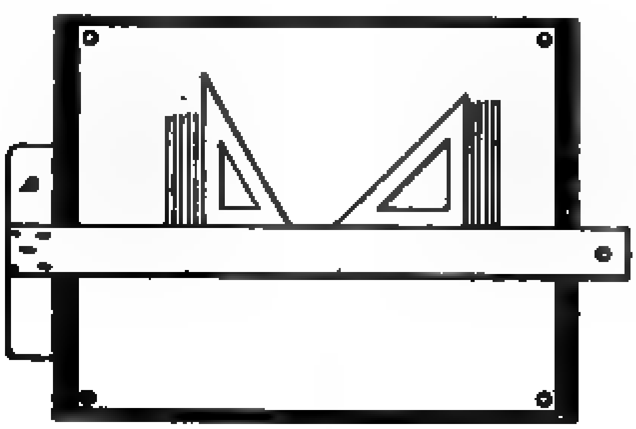

FIG. 5.

4. For drawing parallel lines that are neither vertical nor horizontal, the simplest and best way, when the lines are near together, is to place one edge of a triangle, as *a b*, Fig. 6, on the given line *c d*, and lay the other triangle, as *B*,

against one of the two edges, holding it fast with the left hand; then move the triangle *A* along the edge of *B*. The edge *a b* will be parallel to the line *c d*; and when the edge *a b* reaches the point *g*, through which it is desired to draw the parallel line, hold both triangles stationary with the left

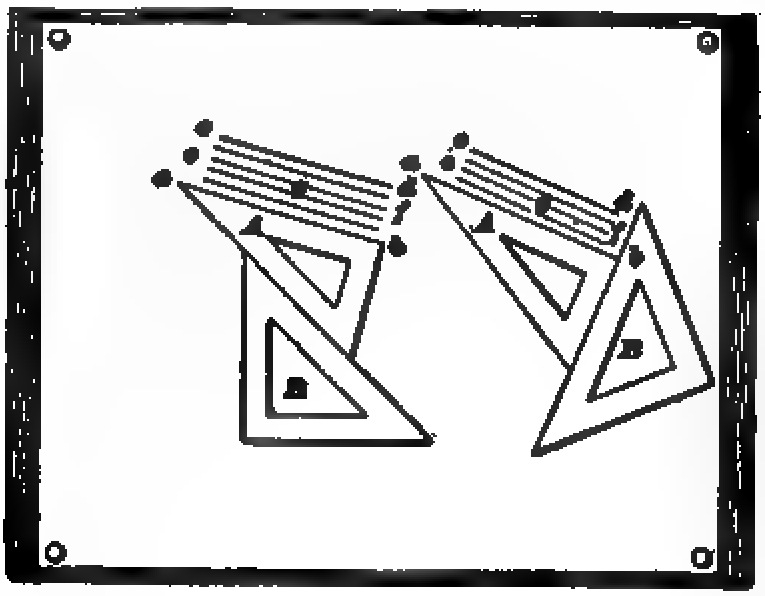

FIG. 6.

hand, and draw the line *e f* by passing the pencil along the edge *a b*. Should the triangle *A* extend too far beyond the edge of the triangle *B* after a number of lines have been drawn, hold *A* stationary with the left hand and shift *B* along the edge of *A* with the right hand, and then proceed as before.

5. A line may be drawn at right angles to another line which is neither vertical nor horizontal, as illustrated in Fig. 7. Let *c d* be the given line (shown at the left-hand side). Place one of the shorter edges, as *a b*, of the triangle *B* so that it will coincide with the line *c d*; then, keeping the triangle in this position, place the triangle *A* so that its long edge will come against the long edge of *B*. Now, holding *A* securely in place with the left hand, slide *B* along the edge of *A* with the right hand, when the lines *h i*, *m n*, etc. may be drawn perpendicular to *c d* along the edge *b f* of the triangle *B*. The dotted lines show the position of the triangle *B* when moved along the edge of *A*.

6. The right-hand portion of Fig. 7 shows another method of accomplishing the same result, and illustrates how the triangles may be used for drawing a rectangular figure, when the sides of the figure make an angle with the T square such that the latter cannot be used.

Let the side cd of the figure be given. Place the *long* side of the triangle B so as to coincide with the line cd, and bring the triangle A into position against the lower side of B, as shown. Now, holding the triangle A in place with the left hand, revolve B so that its other

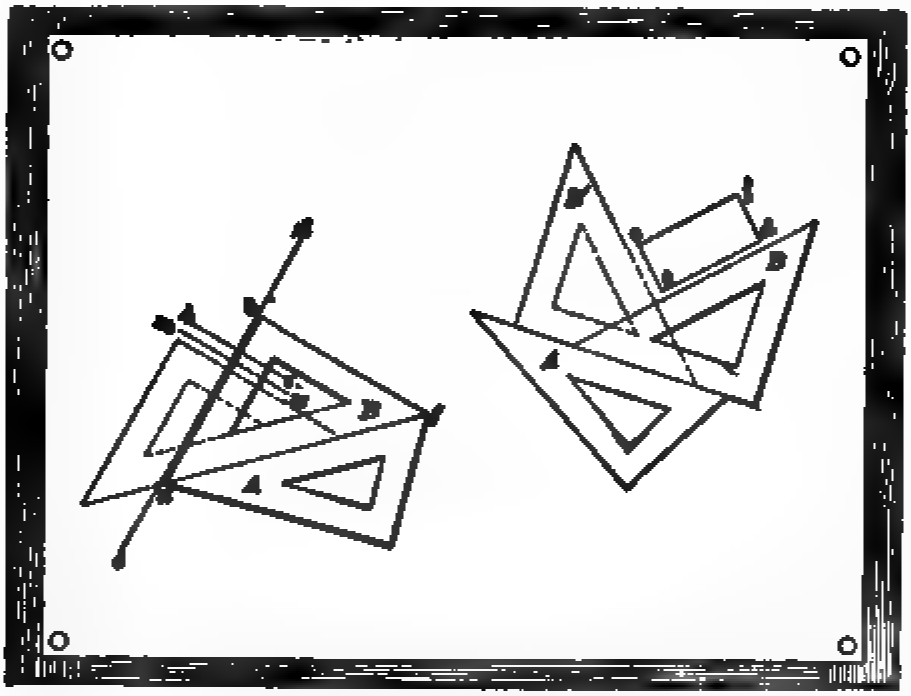

Fig. 7.

short edge will rest against the long edge of A, as shown in the dotted position at B'. The parallel lines ce and df may now be drawn through the points c and d by sliding the triangle B on the triangle A, as described in connection with Fig. 6. Measure off the required width of the figure on the line ce, reverse the triangle B again to its original position, still holding the triangle A in a fixed position with the left hand, and slide B upon A until the long edge of B passes through e. Draw the line ef through the point e, and ef will be parallel to cd. The student should practice with his triangles before beginning drawing.

7. The **compasses**, next to the T square and triangles, are used more than any other instrument. A pencil and pen point are provided, as shown in Fig. 8, either of which may be inserted into a socket in one leg of the instrument, for the drawing of circles in pencil or ink. The other leg is fitted with a needle point, which acts as the center about which the circle is drawn. In all good instruments, the needle point itself is a separate piece of round steel wire, held in place in a socket provided at the end of the leg. The wire should have a square shoulder at its lower end, below which a fine, needle-like point projects. The *lengthening bar*, also shown in the figure, is used to extend the leg carrying the pen and the pencil points when circles of large radii are to be drawn.

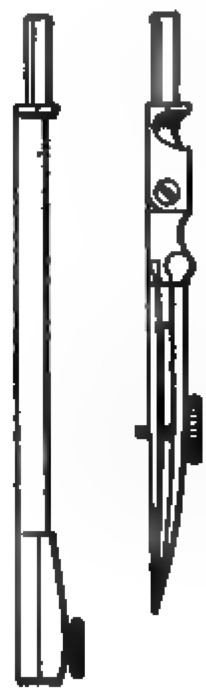

Fig. 8.

The joint at the top of the compasses should hold the legs firmly in any position, and at the same time should permit their being opened or closed with one hand. The joint may be tightened or loosened by means of a screwdriver or wrench, which accompanies the compasses.

It will be noticed in Fig. 8 that each leg of the compasses is jointed; this is done so that the compass points may always be kept perpendicular to the paper when drawing circles, as in Fig. 11.

The style of compasses shown in Fig. 8 have what is called a *tongue joint*, in which the head of one leg has a tongue, generally of steel, which moves between two lugs on the other leg. Another common style of joint is the

pivot joint in which the head of each leg is shaped like a disk and the two disks are held together in a fork-shaped brace either by means of two pivot screws or by one screw penetrating both disks. The brace that forms a part of this

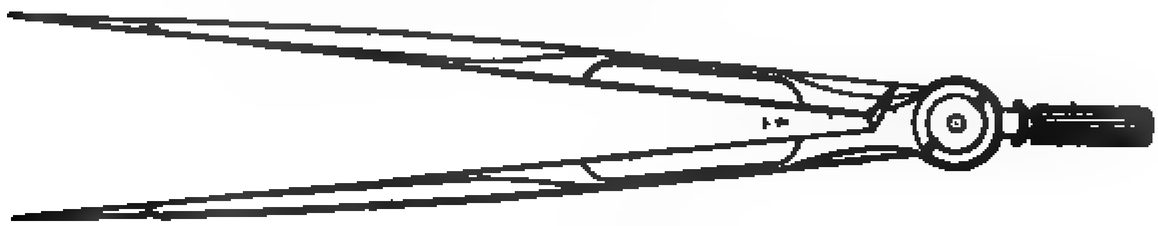

Fig. 9.

joint is generally provided with a handle, as the shape of the joint makes it rather awkward to hold the compasses by the head as is usual with instruments provided with tongue joints. In Fig. 9 is shown a common style of pivot joint.

8. The following suggestions for handling the compasses should be carefully observed by those who are beginning the subject of mechanical drawing. Any draftsman who handles his instruments awkwardly will create a bad impression, no matter how good a workman he may be. The tendency of

Fig. 10.

all beginners is to use both hands for operating the compasses. This is to be avoided. The student should learn at the start to open and close them with one hand, holding them as shown in Fig. 10, with the needle-point leg resting

between the thumb and fourth finger, and the other leg between the middle and forefinger. When drawing circles, hold the compasses lightly at the top between the thumb and forefinger, or thumb, forefinger, and middle finger, as in Fig. 11. Another case where both hands should not be used is in locating the needle point at a point on the drawing about which the circle is to be drawn, unless the left hand is used merely to steady the needle point.

FIG. 11.

Hold the compasses as shown in Fig. 10, and incline them until the under side of the hand rests upon the paper. This will steady the hand so that the needle point can be brought to exactly the right place on the drawing. Having placed the needle at the desired point, and with it still resting on the paper, the pen or pencil point may be moved out or in to any desired radius, as indicated in Fig. 10. When the lengthening bar is used, both hands must be employed.

9. The compasses must be handled in such a manner that the needle point will not dig large holes in the paper. Keep the needle point adjusted so that it will be perpendicular to the paper, when drawing circles, and *do not bear upon it.* A slight pressure will be necessary on the pen or pencil point, *but not on the needle point.*

10. The **dividers**, shown in Figs. 9 and 12, are used for laying off distances upon a drawing, or for dividing straight lines or circles into parts. The points of the dividers should be *very* sharp, so that they will not punch holes in the paper larger than is absolutely necessary to be seen. Compasses are sometimes furnished with two steel divider points, besides the pen and pencil points, so that the instrument may be used either as compasses or dividers. This is the kind illustrated in Fig. 12. When using the dividers to

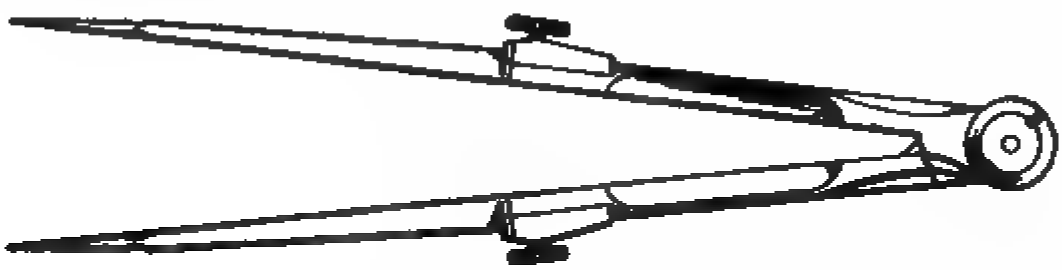

FIG. 12.

space a line or circle into a number of equal parts, hold them at the top between the thumb and forefinger, as when using the compasses, and step off the spaces, turning the instrument alternately to the right and left. If the line or circle does not space exactly, vary the distance between the divider points and try again; so continue until it is spaced equally. When spacing in this manner, great care must be exercised not to press the divider points into the paper; for, if the points enter the paper, the spacing can never be accurately done. The student should satisfy himself of the truth of this statement by actual trial.

11. The **bow-pencil** and **bow-pen**, shown in Fig. 13, are convenient for describing small circles. The two points of the instruments must be adjusted to the same length:

otherwise, very small circles cannot be drawn. To open or close either of these instruments, support it in a vertical position by resting the needle point on the paper and bearing slightly on the top of it with the forefinger of one hand, and turn the adjusting nut with the thumb and middle finger of the same hand.

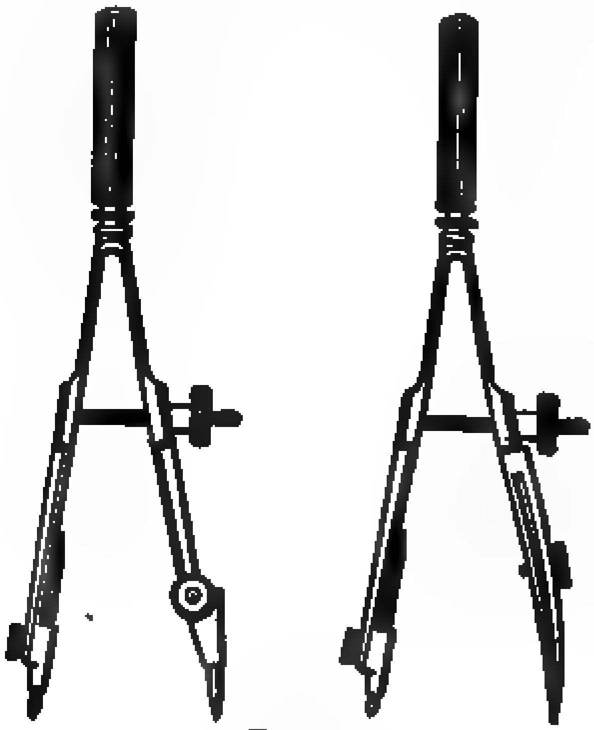

Fig. 13.

12. Drawing Paper and Pencils.—The drawing paper recommended for this series of lessons is the T. S. Co.'s cold-pressed demy, the size of which is $15'' \times 20''$. It takes ink well, and withstands considerable erasing. The paper is secured to the drawing board by means of **thumbtacks.** Four are usually sufficient—one at each corner of the sheet (see Fig. 7). Place a piece of paper on the drawing board, and press a thumbtack through one of the corners about $\frac{1}{4}$ or $\frac{3}{8}$ of an inch from each edge. Place the T square in position for drawing a horizontal line, as before explained, and straighten the paper so that its upper edge will be parallel to the edge of the T square blade. Pull the corner diagonally opposite that in which the thumbtack was placed, so as to stretch the paper slightly, and push in another thumbtack. Do the same with the remaining two corners. For drawing in pencil, an HHHH pencil of any reputable make should be used. The pencil should be sharpened as shown at A, Fig. 14.

Fig. 14.

Cut the wood away so as to leave about $\frac{1}{4}$ or $\frac{3}{8}$ of an inch of the lead projecting; then sharpen it flat by rubbing it against a fine file or a piece of fine emery cloth or sandpaper that has been fastened to a flat stick. Grind it to a sharp edge like a knife blade, and round the corners very slightly, as shown in the figure. If sharpened to a round point, as shown at B, the point will wear away very quickly and make broad lines; when so sharpened it is difficult to draw a line exactly through a point. The lead for the compasses should be sharpened in the same manner as the pencil, but should have its width narrower. *Be sure that the compass lead is so secured that, when circles are struck in either direction, but one line will be drawn with the same radius and center.*

13. Inking.—For drawing ink lines other than arcs of circles, the **ruling pen** (or *right-line pen*, as it is sometimes called) is used. It should be held as nearly perpendicular to the board as possible, with the hand in the position shown in Figs. 15 and 16, bearing lightly against the T square

FIG. 15.

or triangle, along the edge of which the line is drawn. After a little practice, this position will become natural, and no difficulty will be experienced.

14. The beginner will find that it is not always easy to make smooth lines. If the pen is held so that only one blade bears on the paper when drawing, the line will almost invariably be ragged on the edge where the blade does not bear. When held at right angles to the paper, as in Fig. 16, how-

FIG. 16.

ever, both blades will rest on the paper, and if the pen is in good condition, smooth lines will result. The pen must not be pressed against the edge of the T square or triangle, as the blades will then close together, making the line uneven. The edge should serve as a guide, simply.

In drawing circles with the compass pen, the same care should be taken to keep the blades perpendicular to the paper by means of the adjustment at the joint. In both the ruling pen and compass pen, the width of the lines can be altered by means of the screw which holds the blades together. The handles of most ruling pens can be unscrewed and are provided with a needle point intended for use

when copying maps by pricking through the original and the underlying paper, thus locating a series of points through which the outline may be drawn.

15. Drawing Ink.—The ink we recommend for the work in this course is the T. S. Co.'s superior waterproof liquid India ink. A quill is attached to the cork of every bottle of this ink, by means of which the pen may be filled. Dip the quill into the ink, and then pass the end of it between the blades of the drawing pen. Do not put too much ink in the pen, not more than enough to fill it for a quarter of an inch along the blades, otherwise the ink is liable to drop. Many draftsmen prefer to use stick India ink; and, for some purposes, this is to be preferred to the prepared liquid ink recommended above. In case the stick ink is bought, put enough water in a shallow dish (a common individual butter plate will do) to make enough ink for the drawing, then place one end of the stick in the water, and grind by giving the stick a circular motion. Do not bear hard upon the stick. Test the ink occasionally to see if it is black. Draw a fine line with the pen, and hold the paper in a strong light. If it shows brown (or gray), grind a while longer, and test again. Keep grinding until a fine line shows *black*, which will usually take from fifteen minutes to half an hour, depending upon the quantity of water used. The ink should always be kept well covered with a flat plate of some kind, to keep out the dust and prevent evaporation. The drawing pen may be filled by dipping an ordinary writing pen into the ink and drawing it through the blades, as previously described when using the quill. If liquid ink is used, all the lines on all the drawings will be of the same color, and no time will be lost in grinding. If stick ink is used, it is poor economy to buy a cheap stick. A small stick of the best quality, costing, say, a dollar, will last as long, perhaps, as five dollars' worth of liquid ink. The only reason for using liquid ink is that all lines are then sure to be of equal blackness, and time is saved in grinding.

India ink will dry quickly on the drawing, which is

desirable, but it also causes trouble by drying between the blades and refusing to flow, especially when drawing fine lines. *The only remedy is to wipe out the pen frequently* with a cloth. Do not lay the pen down for any great length of time when it contains ink; wipe it out first. The ink may sometimes be started by moistening the end of the finger and touching it to the point, or by drawing a slip of paper between the ends of the blade. *Always keep the bottle corked.*

16. To Sharpen the Drawing Pen.—When the ruling, or compass, pen becomes badly worn, it must be sharpened. For this purpose a fine oilstone should be used. If an oilstone is to be purchased, a small, flat, close-grained stone should be obtained, those having a triangular section being preferable, as the narrow edge can be used on the inside of the blades in case the latter are not made to swing apart so as to permit the use of a thicker edge.

The first step in sharpening is to screw the blades together, and, holding the pen perpendicular to the oilstone, to draw it back and forth over the stone, changing the slope of the pen from downward and to the right to downward and to the left for each movement of the pen to the right and left. The object of this is to bring the blades to exactly the same length and shape, and to round them nicely at the point.

This process, of course, makes the edges even duller than before. To sharpen, separate the points by means of the screw, and rub one of the blades to and from the operator in a straight line, giving the pen a slight twisting motion at the same time, and holding it at an angle of about 15° with the face of the stone. Repeat the process for the other blade. To be in good condition the edges should be fairly sharp and smooth, but not sharp enough to cut the paper. *All the sharpening must be done on the outside of the blades.* The inside of the blades should be rubbed on the stone only enough to remove any burr that may have been formed. Anything more than this will be likely to injure the pen. The whole operation must be done very carefully,

bearing on lightly, as it is easy to spoil a pen in the process. Examine the points frequently, and keep at work until the pen will draw both *fine* lines and *smooth* heavy lines. Many draftsmen prefer to send the pens to be sharpened to the dealer who sold them and who is generally willing to do such sharpening at a trifling cost.

17. Irregular Curves.—Curves other than arcs of circles are drawn with the pencil or ruling pen by means of curved or irregular-shaped rulers, called **irregular curves** (see Fig. 17). A series of points is first determined through which the curved line is to pass. The line is then drawn through these points by using such parts of the irregular curve as will pass through several of the points at once, the curve being shifted from time to time as required.

It is usually difficult to draw a smooth, continuous curve. The tendency is to make it curve out too much between the points, thus giving it a wavy appearance, or else to cause it to change its direction abruptly where the different lines join, making angles at these points. These defects may largely be avoided by always fitting the curve to at least three points, and, when moving it to a new position, by setting it so that it will coincide with part of the line already drawn. It will be found to be a great help if the line be first sketched in freehand, in pencil. It can then be penciled over neatly, or inked, without much difficulty, with the aid of the irregular curve, since the original pencil line will show the general direction in which the curve should be drawn. Whenever the given points are far apart, or fall in such positions that the irregular curve cannot always be made to pass through three of them, the line must invariably be sketched in at first.

FIG. 17.

As an example, let it be required to draw a curved line through the points *a*, *b*, *c*, *d*, etc., Fig. 18. As just stated, a part of the irregular curve must be used which will pass through at least three points. With the curve set in the first position *A*, its edge is found to coincide with four points *a*, *b*, *c*, and *d*. The line may then be drawn from *a* around to *d*, or, better, to a point between *c* and *d*, since, by not con-

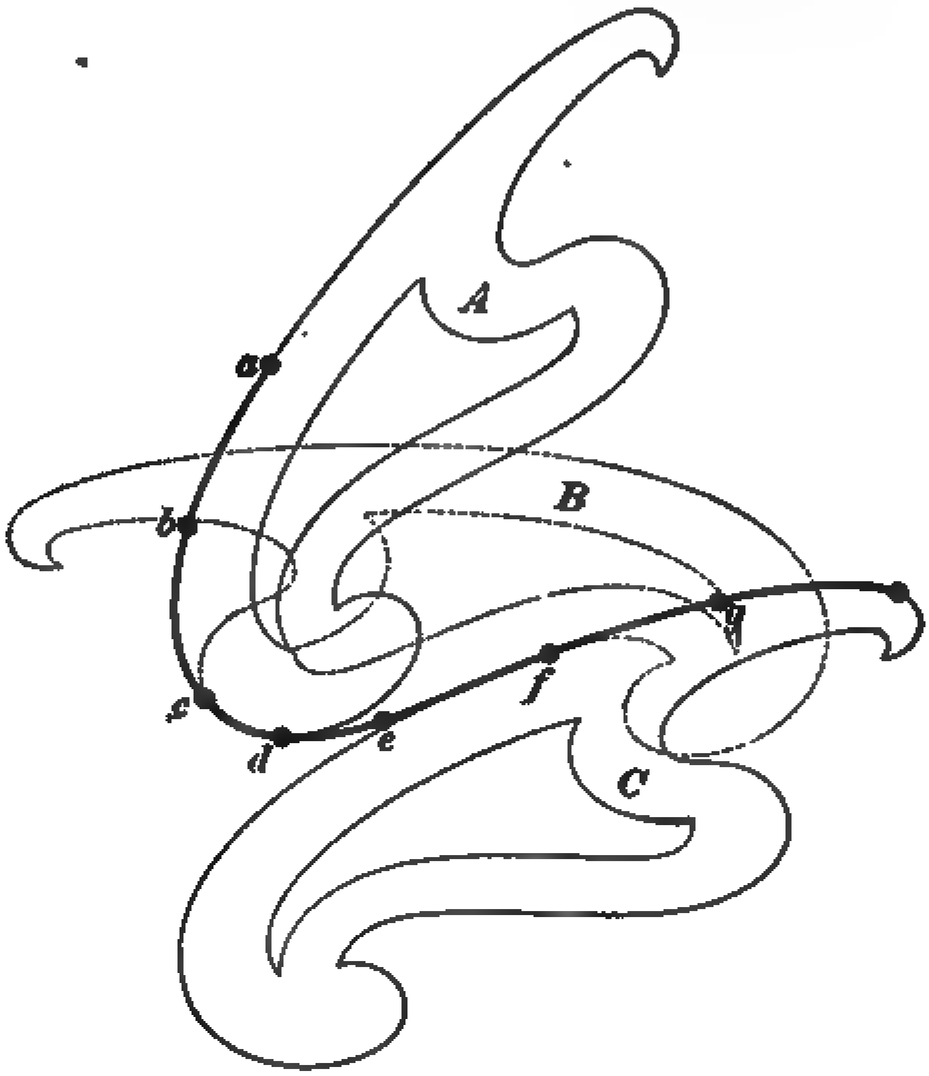

FIG. 18.

tinuing it quite to *d*, there is less liability of there being an angle where the next section joins on. For the next section of the line, the curve should be adjusted so as to coincide with a part of the section already drawn; that is, instead of adjusting it to points *d*, *e*, *f*, etc., it should be placed so as to pass through the point *c*, the part from *c* to *d* being coincident with the corresponding part of the first line drawn.

The irregular curve is shown dotted in this position at *B*. Its edge passes through four points *c*, *d*, *e*, and *f*, and the line should be made to stop midway between the last two, as before.

Now, it will be noticed that the points *f* and *g* are so situated that the remainder of the line must curve up, instead of down, as heretofore, the change in curvature occurring at a point between *e* and *f*. In this case, therefore, it is not necessary for the curve to extend back to *e*, through which point the line has already been drawn, but it may be placed in position *C* with its edge just tangent to the line at the point where the curvature changes.

It is to be noticed that in inking with the irregular curve, the blades of the pen must be kept tangent to its edge (i. e., the inside flat surface of the blades must have the same direction as the curve at the point where the pen touches the paper), which requires that the direction of the pen be continually changed.

18. The **scale** is used for obtaining measurements for drawings. The most convenient forms are the usual flat and triangular boxwood scales, having beveled edges, each of which is graduated for a distance of 12 inches. The beveled edges serve to bring the lines of division close to the paper when the scale is lying flat, so that the drawing may be accurately measured, or distances laid off correctly. The use of the graduations on scales will be explained when it is necessary to use the scale.

19. A **protractor** is shown in Fig. 19. The outer edge is a semicircle, with center at *O*, and is divided into 360 parts. Each division is one-half of one degree, and, for convenience, the degrees are numbered from 0° to 180° from both *A* and *B*. The protractor is used for laying off or measuring angles. Protractors are often made of metal, in which case the central part is cut away to make the drawing under it visible. When using the protractor, it must be placed so that the line *O B*, Fig. 19, will coincide with the

line forming one side of the angle to be laid off or measured, and the center O must be at the vertex of the angle.

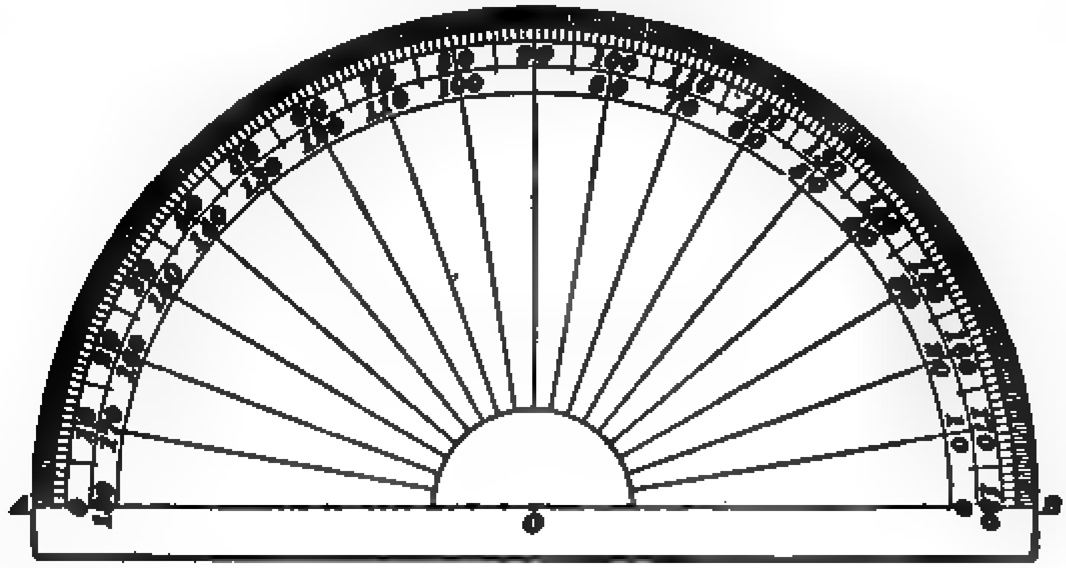

FIG. 19.

For example, let it be required to draw a line through the point C, making an angle of 54° with the line $E\,F$, Fig. 20. Place the protractor upon the line $E\,F$, as just described, with the center O upon the point C. With a sharp-pointed pencil, make a mark on the paper at the 54° division, as indicated at D. A line drawn through C and D will then make an angle of 54° with $E\,F$. Greater exactness will be secured

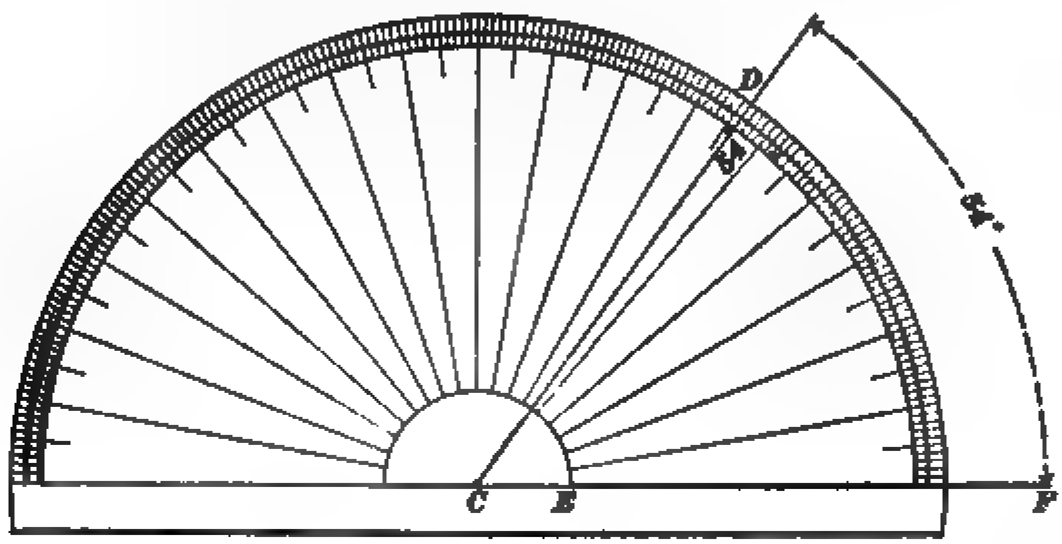

FIG. 20.

if the line $E\,F$ be extended to the left, so that both zero marks (A and B, Fig. 19) can be placed on the line. This should always be done when possible.

LETTERING.

20. In mechanical drawing, all headings, explanatory matter, and dimensions should be neatly printed on the drawing. Ordinary script writing is not permissible.

It is usually difficult for beginners to letter well, and unless the student is skilful at it, he should devote some time to practicing lettering before commencing the drawing. In correcting the plates, the lettering will be considered as well as the drawing. Many students think that it is only necessary to exercise special care when drawing the views on a plate, and that it is not necessary to take particular pains in lettering. This, however, is not the case, for, no matter how well the views may be drawn, if the lettering is poorly done, the finished drawing will not have a neat appearance. In fact, generally speaking, more time is required to make well-executed letters than to make well-executed drawings of objects. We earnestly request the student to practice lettering, and not to think that that part of the work is of no importance. The student should not be too hasty in doing the lettering. It takes an experienced draftsman considerable time to do good lettering, and no draftsman can perform this work as quickly as he can ordinary writing; therefore, no beginner should attempt to do what experienced draftsmen cannot do. In order to letter well, the work must be done slowly. Very frequently more time is spent in lettering a drawing than in inking in the objects represented. Instructions will be given in two styles of freehand lettering, both extensively used in American drafting rooms.

With the exception of the large headings or titles of the plates, the style and size of all lettering used on the original

ABCDEFGHIJKLMNOPQRSTUVWXYZ
abcdefghijklmnopqrstuvwxyz &
1234567890 1234567890 2'-6½" dia. Cast Iron

FIG. 21.

drawing plates of this course are shown in Fig. 21. This style, although a little more elaborate and difficult in execution, was selected on account of its greater neatness and

legibleness. The two styles are very similar in the formation of the letters, and although the student is advised to select and use only one of the two on his drawings in this course, he will find, after having mastered one of the styles, little difficulty in practicing the other.

When lettering, a Gillott's No. 303 pen should be used. The height of the capital letters should be $\frac{3}{32}''$, and of the small letters two-thirds of this, or $\frac{1}{16}''$. This applies to both styles of freehand lettering. *Do not make them larger than this.*

21. Before beginning to letter, horizontal guide lines should be drawn with the T square, to serve as a guide for the tops and bottoms of the letters (see Fig. 22). The outside lines should be $\frac{3}{32}''$ apart for the capitals, and the two lower lines $\frac{1}{16}''$ apart for the small letters. The letters should be made to extend fully up to the top and down to the bottom guide lines. They must not fall short of the guide lines, nor extend beyond them.

FIG. 22.

Failure to observe this point will cause the lettering to look ragged, as in the second word in Fig. 22.

22. It is very important that all the letters have the same inclination. For example, by referring to Fig. 23 (*a*), it will be seen that the backs of letters like *B*, *E*, *l*, *g*, *d*, *i*, *t*, etc. are parallel and slant the same way. This is also true of both sides of letters like *H*, *M*, *n*, *u*, *h*, *y*, etc. To aid in keeping the slant uniform, draw parallel slanting lines across the guide lines with the 60° triangle, as in Fig. 23 (*b*), and, in lettering, make the backs or sides of the letters parallel with these lines.


FIG. 23 (*a*).

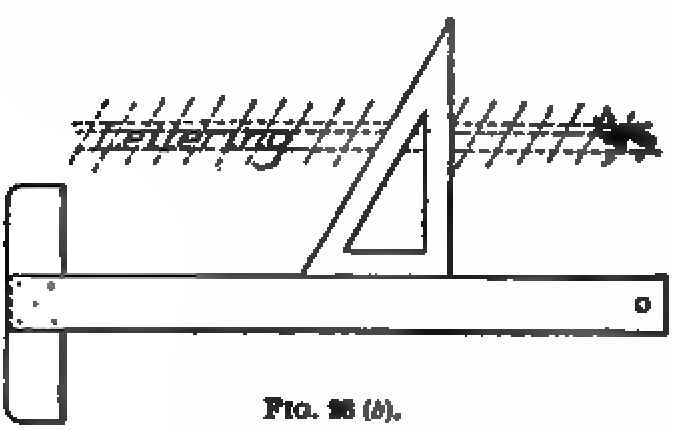

FIG. 23 (*b*).

23. A few points regarding the construction of the letters are illustrated in Fig. 24, in which the letters are shown upon an enlarged scale. The capital letters *A*, *V*, *Y*, *M*, and *W* must be printed so that their general inclination will be the same as for the other letters. To print the *A*, draw the center line *a d*, having the common slant; from

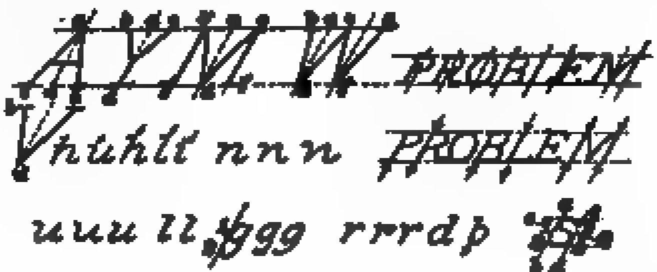

FIG. 24.

a draw the sides *a c* and *a b*, so that points *c* and *b* will each be $\frac{3}{64}''$ distant from point *d*. The side *a b* will be nearly perpendicular to the guide lines. The *V* is like an inverted *A*, and is drawn in the same way, the line *b d* being nearly perpendicular.

To make the *Y*, draw the center line *a d*, having the common slant, which gives the slant for the base of the letter. The upper part of the *Y* begins a little below its center, and is similar to the *V*, though somewhat narrower, as the letter should be only $\frac{3}{32}''$ wide at the top. Points *b* and *c* should be at equal distances from point *a*.

The two sides *b c* and *e f* of the *M* are parallel, and have the common slant. The *M* is made as broad as it is high, or $\frac{3}{32}''$. Having drawn the two sides, mark the point *d*, midway between the points *c* and *f*, and connect it with points *b* and *e*. The lines *b d* and *e d* should be slightly curved, as shown.

In the *W* the two outside lines are not parallel, as in the *M*, but are farther apart at the top than at the bottom. Draw the line *a d*, having the common slant. Mark points *b* and *c*, which are exactly $\frac{1}{32}''$ from the point *a*. From *b* and *c* draw lines *b d* and *c d*. The other half of the *W* is like the first part, *c f* being parallel to *b d* and *e f* parallel to *c d*. It will be seen that the *W* is composed of two narrow *V*'s, each $\frac{1}{16}''$ wide, the width of the whole letter being $\frac{1}{8}''$.

24. Capital letters like *P*, *R*, *B*, *L*, *E*, etc. should be printed so that their top and bottom lines will be *exactly*

horizontal. This is illustrated in the two examples of the word *problem* in Fig. 24. In the first example, it will be noticed that the tops of the *P* and *R*, the bottom of the *L*, and the tops and bottoms of the *B* and *E*, all run in the same direction as the guide lines, and coincide with them. In the second example, these lines are not horizontal, which makes the word look very uneven. It is also to be noticed that these lines extend beyond the upright lines in the first word, and that cross-lines are used on the bottom of the *P* and *R*, on the top of the *L*, and on the *M*. In the second word, these lines are omitted at the points indicated by the arrows. These features are found on most of the other capitals.

The small letters *n*, *u*, *h*, *l*, *i*, etc. should have sharp corners at the points indicated by the arrows in Fig. 24. They look much better that way, and are less difficult to make, than when they have round corners. Following these letters are five groups of letters containing *n*, *u*, *l*, *g*, and *r*. The first letter of each group is printed correctly, while the letters following show ways in which they should *not* be printed. In the case of the *g*, point *2* should fall in a slanting direction under point *1*, the slant being the same as *a d* of the preceding letters. The difference between *d* and *b* and the construction of the *s* are also shown in the same figure. The *b* should be made rounding at the point indicated. As a guide in making the *s*, draw the two lines *a b* and *c d*, having the common slant. The *s* should now be drawn so that it will touch these lines at points *1*, *3*, and *4*, but *not* at point *2*. It will be an additional help if the line *e x* is also drawn as a guide for the middle portion of the *s*; but care should be taken not to have it slant more than shown in the copy.

The letters *a*, *o*, *b*, *g*, etc. should be full and round; do not cramp them. It will be necessary to follow the copy closely until familiar with it. Notice that the figures are not made as in writing, particularly the *6*, *4*, *8*, and *9* (see Fig. 21). Try to space the letters evenly. Letter in pencil first, and, if not right, erase and try again.

25. Another style of freehand lettering is shown in Fig. 25. This style is extensively used for the lettering of working drawings. It is more easily and rapidly

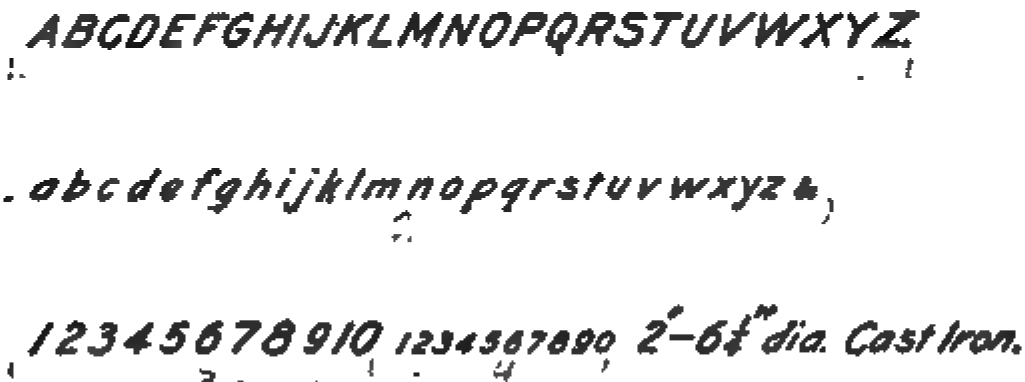

FIG. 25.

made than the style previously described, and although not productive of as high degree of neatness in appearance will be found very useful and acceptable for general office work.

A comparison between the two systems will disclose a great similarity in the detail formation of the letters.

26. The horizontal and slanting guide lines are drawn exactly in the same manner as for the style previously described, and if not followed the results will be similar. See the uneven appearance of the second word in Fig. 26.

FIG. 26.

27. By studying the formation of the letters carefully, it will be found that many of them are formed on the same principle, as shown in Fig. 27. The ovals of the letters *a*, *b*, *d*, *g*, *p*, and *q* are formed exactly alike and have a slant of 45° with the horizontal. These ovals should be made a little wider at the top than at the bottom. Care should be taken that the straight downward strokes are made parallel to the slanting guide lines. The letters *c* and *e* are commenced in the same way, but the upper loop in *e* should be formed in such a manner that its axis will be at an angle

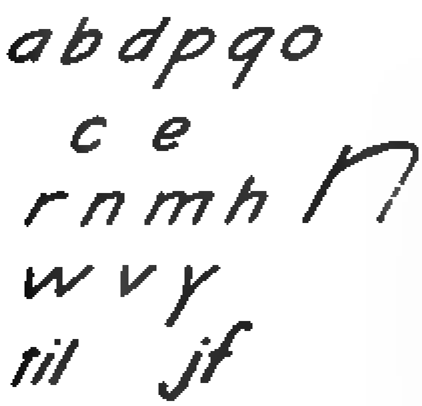

FIG. 27.

of 45° with the horizontal. The *r* is made by having the down stroke parallel to the slanting guide line and the up stroke slightly curved in the same way as in the letter *n* (see Fig. 27). The strokes in the letters *j* and *f* are the same, with the position of the hooked part reversed.

28. The capital letters shown in Fig. 28 are formed very nearly in the same manner as those shown in Art. **23,**

A Y M W

V PROBLEM

FIG. 28.

but differ slightly by omitting the short spurs that give to the letters a more finished appearance.

In the capital *M*, however, there is a decided variation. The *M* is made with four strokes, putting in the parallel sides first. The two other strokes should join midway between these sides and at a distance from the top of about $\frac{3}{8}$ of the height of the letter. These strokes, as will be seen, are straight and not curved.

29. The *numerals* should be $\frac{5}{32}''$ high and of the style shown in Fig. 25; fractions should be $\frac{1}{4}''$ high over all. In

1 2 3 4 5 6 7 8 9 0

FIG. 29.

Fig. 29 the numerals are illustrated to a larger scale, and a comparison with the style shown in Fig. 21 will disclose several variations.

The loops of the *2*, *3*, *5*, *6*, and *9* should be formed so that their axes will be at an angle of 45° with the horizontal. It will be noted that the *7* differs widely from the style shown in Fig. 21, the down stroke not curving but having a straight slant of 45°. The axis of the *0* and the loops of the *8* should slant at an angle of 60°.

Diligent practice for a short time and careful observation of the forms of letters and numerals as shown in Figs. 21–29 will soon enable the student to acquire skill and speed in this branch of drawing.

30. The alphabet shown in Fig. 30, called the **block letter,** is to be used for the large headings or titles of plates, as shown on the copy plates. This alphabet is *not* to be used on the first five geometrical drawing plates. The letters and figures are to be made $\frac{5}{16}''$ high and $\frac{1}{2}''$ wide, except *M*, which is $\frac{9}{16}''$ wide, and *W*, which is $\frac{5}{8}''$ wide. The thickness of all

A B C D E F G H I J
K L M N O P Q R S
T U V W X Y Z & ; : ,
1 2 3 4 5 6 7 8 9 0

FIG. 30.

the lines forming the letters is $\frac{1}{16}''$, measured horizontally. The distance between any two letters of a word is $\frac{1}{16}''$, except where *A* follows *P* or *F*; where *V*, *W*, or *Y* follows *L*; where *J* follows *F*, *P*, *T*, *V*, *W*, or *Y*; where *T* and *A* are adjacent, or *A* and *V*, *W*, or *Y* are adjacent; in this case, the bottom extremity of *A* and the top extremity of *P*, *T*, *V*, *W* are in the same vertical line, etc.

31. Since these letters are composed of straight lines, they can be made with the T square and triangle. In lettering the title of the drawing plates, the student should draw six horizontal lines $\frac{1}{16}''$ apart in lead pencil, to represent the thickness of the letters at the top, center, and bottom; then, by use of the triangle, he should draw in the width of the letters and the spaces between them in lead pencil. Having the

letters all laid out, he can very easily ink them in. Use the ruling pen for inking in the straight outlines of the letters, and the lettering pen for rounding the corners and filling in between the outlines. It is well to ink in all the perpendicular lines first, next the horizontal lines, and then the oblique lines.

PLATES.

32. Preliminary Directions.—The size of each plate over all will be 14″ × 18″, having a border line ½″ from each edge all around, thus making the size of the space on which the drawing is to be made 13″ × 17″. The sheet itself must be larger than this when first placed upon the board, so that the thumbtack holes may be cut out; the extra margin is also very convenient for testing the pen, in order to see whether the ink is flowing well and whether the lines are of the proper thickness.

The first five plates will consist of practical geometrical problems which constantly arise in practice when making drawings. The method of solving every one of these problems should be carefully memorized, so that they can be instantly applied when the occasion requires, without being obliged to refer to the text for help. Particular attention should be paid to the lettering. Whenever any dimensions are specified, they should be laid off as accurately as possible. All drawings should be made as neat as possible, and the penciling entirely finished before inking in any part of it. Great care should be taken in distributing the different views, parts, details, etc. on the drawing, so that when the drawing is completed, one view will not be so near to another as to mar the appearance of the drawing. The hands should be perfectly clean, and should not touch the paper except when necessary. No lines should be erased except when *absolutely* necessary; for, whenever a line has once been erased, the dirt flying around in the air and constantly falling on the drawing will stick to any spot where an

erasure has been made, and it is then very difficult, if not impossible, to entirely remove it. For this reason, all construction lines that are to be removed, or that are liable to be changed, should be drawn lightly, that the finish of the paper may not be destroyed when erasing them. When it is found necessary to erase an ink blot or a line that has been inked in, only an *ink eraser* or *sand rubber* should be used. After the erasure has been made, the roughened part of the surface of the paper can be smoothed by rubbing with some hard, smooth substance, as a piece of ivory or the handle of a knife.

PLATE I.

33. Take a sheet of drawing paper 15″ wide and 20″ long (demy size), and fasten it to the board as previously described. On this draw the outlines of the size of the plate, 14″ × 18″, and draw the border line all around ½″ from the edge of the outline, leaving the space inside for the drawing 13″ × 17″. When the word *drawing* is used hereafter, it refers only to the space inside the border lines and the objects drawn upon it. To understand clearly what follows, refer to Plate I. Divide the drawing into two equal parts by means of a faint horizontal line. This line is shown dotted in Plate I, above referred to. Divide each of these halves into three equal parts, as shown by the dotted lines; this divides the drawing into six rectangular spaces. *These division lines are not to be inked in, but must be erased when the plate is completed.* On the first five plates, space for the lettering must be taken into account. For each of the six equal spaces, the lettering will take up one or two lines. The height of all capital letters on these plates will be $\frac{3}{32}$″, and of the small letters ⅔ of this, or $\frac{1}{16}$″. The distance between any two lines of lettering will also be $\frac{3}{32}$″. The distance between the tops of the letters on the first line of lettering and the top line of the equal divisions of the drawing is to be ¼″; and the space between the bottoms of the letters and the topmost point of the figure represented on the

drawing within one of these six divisions must also be not less than $\frac{1}{2}''$. This makes a very neat arrangement, if the figure is so placed that the outermost points of the bounding lines are equally distant from the sides of one of the equal rectangular spaces. Consequently, if there is one line of lettering, no point of the figure drawn should come nearer than $\frac{1}{2}'' + \frac{3}{32}'' + \frac{1}{2}'' = 1\frac{3}{32}''$ to the top line of the space within which it is represented; or, if there are two lines of lettering, nearer than $\frac{1}{2}'' + \frac{3}{32}'' + \frac{3}{32}'' + \frac{3}{32}'' + \frac{1}{2}'' = 1\frac{9}{32}''$. The letter heading for each figure on the first five plates will be printed in heavy-faced type at the beginning of the directions explaining each problem. The student must judge for himself by the length of the heading whether it will take up one line or two, and make due allowance for the space it takes up. This is a necessary precaution, because the lettering should never be done until the rest of the drawing is entirely finished and inked in.

PROBLEM 1.—**To bisect a straight line.**

See Fig. 31; also 1 of Plate I.

CONSTRUCTION.—Draw a straight line AB, $3\frac{1}{2}''$ long. With one extremity A as a center, and a radius greater than one-half of the length of the line, describe an arc of a circle on each side of the given line; with the other extremity B as a center, and the same radius, describe arcs intersecting the first two in the points C and D. Join C and D by the line CD, and the point P, where it intersects AB, will be the required point; that is, $AP = PB$, and P is the middle point of AB. Since CD is perpendicular to AB, this construction also gives a *perpendicular to a straight line at its middle point.*

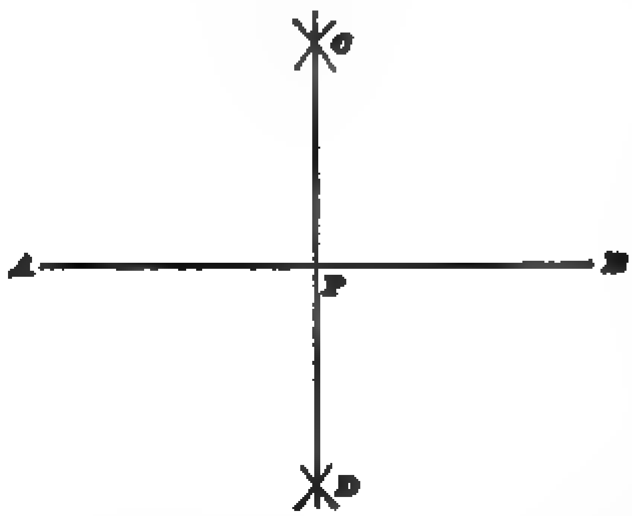

FIG. 31.

PROBLEM 2.—**To draw a perpendicular to a straight line from a given point in that line.**

NOTE.—As there are two cases of this problem, requiring two figures on the plate, the line of letters will be run clear across both figures, as shown in Plate I.

Case I.—*When the point is at or near the center of the line.* See Fig. 32; also 2, Case I, of Plate I.

CONSTRUCTION.—Draw $A\,B$ $3\frac{1}{2}''$ long. Let P be the given point. With P as a center, and any radius, as $P\,D$, describe two short arcs cutting $A\,B$ in the points C and D. With C and D as centers, and any convenient radius greater than $P\,D$, describe two arcs intersecting in E. Draw $P\,E$, and it will be perpendicular to $A\,B$ at the point P.

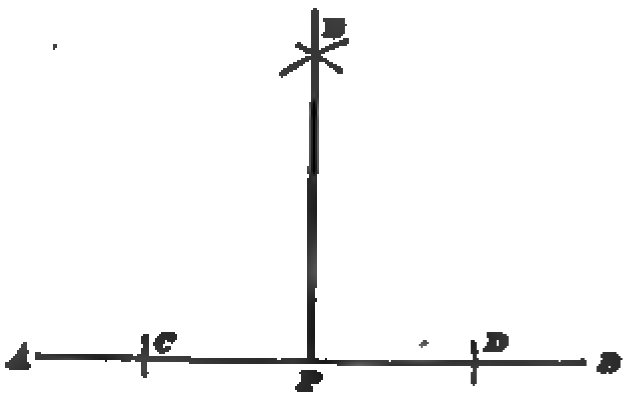

FIG. 32.

Case II.—*When the point is near the end of the line.* See Fig. 33; also 2, Case II, of Plate I.

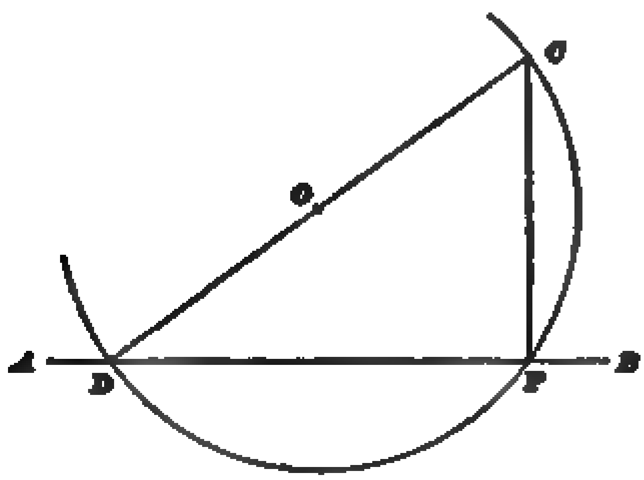

FIG. 33.

Draw $A\,B$ $3\frac{1}{2}''$ long. Take the given point P about $\frac{1}{2}''$ from the end of the line. With any point O as a center, and a radius $O\,P$, describe an arc cutting $A\,B$ in P and D. Draw $D\,O$, and prolong it until it intersects the arc in the point C. A line drawn through C and P will be perpendicular to $A\,B$ at the point P.

PROBLEM 3.—**To draw a perpendicular to a straight line from a point without it.**

As in Problem 2, there are two cases.

Case I.—*When the point lies nearly over the center of the line.* See Fig. 34; also 3, Case I, of Plate I.

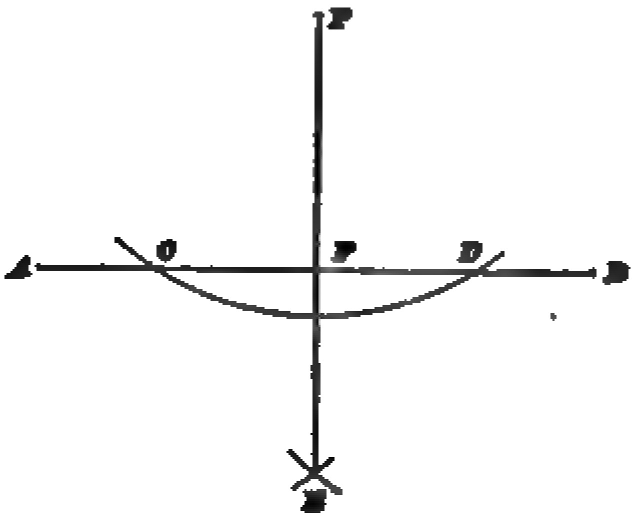

Fig. 34.

Construction.—Draw $A\,B$ $3\frac{1}{2}''$ long. Let P be the given point. With P as a center, and any radius $P\,D$ greater than the distance from P to $A\,B$, describe an arc cutting $A\,B$ in C and D. With C and D as centers, and any convenient radius, describe short arcs intersecting in E. A line drawn through P and E will be perpendicular to $A\,B$ at F.

Case II.—*When the point lies nearly over one end of the line.* See Fig. 35; also 3, Case II, of Plate I.

Draw $A\,B$ $3\frac{1}{2}''$ long, and let P be the given point. With any point C on the line $A\,B$ as a center, and the distance $C\,P$ as a radius, describe an arc $P\,E\,D$ cutting $A\,B$ in E. With E as a center, and the distance $E\,P$ as a radius, describe an arc cutting the arc $P\,E\,D$ in D. The line joining the points P and D will be perpendicular to $A\,B$.

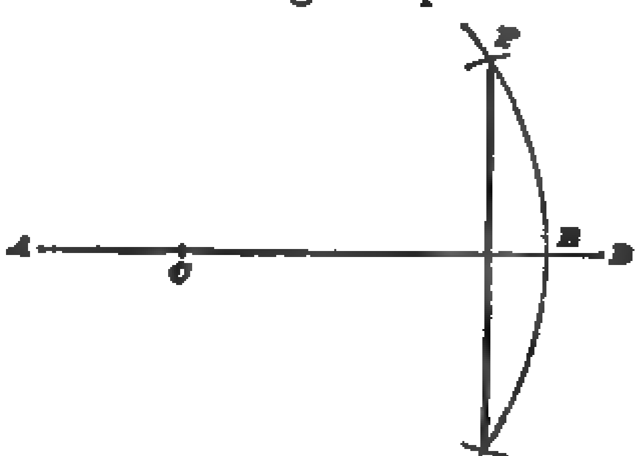

Fig. 35.

Problem 4.—**Through a given point, to draw a straight line parallel to a given straight line.**

See Fig. 36; also 4 of Plate I.

Construction.—Let P be the given point, and $A\,B$ the given straight line $3\frac{1}{2}''$ long. With P as a center, and any

convenient radius, describe an arc CD intersecting AB in D. With D as a center, and the same radius, describe the arc PE. With D as a center, and a radius equal to the chord of the arc PE, describe an arc intersecting CD in C. A straight line drawn through P and C will be parallel to AB.

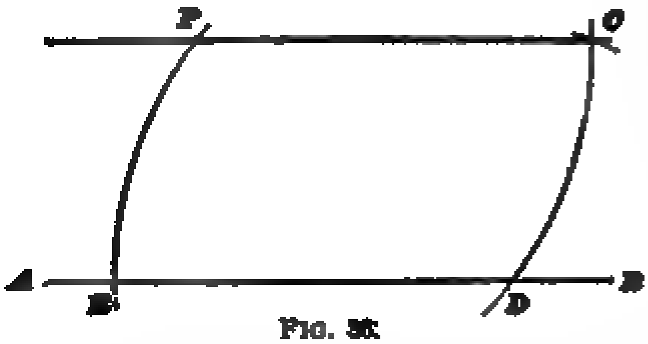

FIG. 36.

34. These four problems form Plate I. They should be carefully and accurately drawn in with lead-pencil lines and then inked in. It will be noticed that on Plate I, and Figs. 31 to 36, the given lines are *light*, the required lines *heavy*, and the construction lines, which, in a practical working drawing, would be left out, are *light dotted*. This system must also be followed in the four plates which are to follow. A single glance enables one to see at once the reason for drawing the figure, and the eye is directed immediately to the required line.

In the first five plates, accuracy and neatness are the main things to be looked out for. The student should be certain that the lines are of *precisely* the length that is specified in the description. When drawing a line through two points, be sure that the line goes through the points; if it does not pass exactly through the points, erase it and draw it over again. If a line is supposed to end at some particular point, make it end there—do not let it extend beyond or fall short. Thus, in Fig. 36, if the line PC does not pass through the points P and C, it is not parallel to AB. By paying careful attention to these points, the student saves himself a great deal of trouble in the future. *Do not hurry your work.*

First ink in all of the light lines and light dotted lines (which have the same thickness); then ink in the heavy required lines after the pen has been readjusted. Now do the lettering (first read carefully the paragraphs under the head "Lettering"), and finally draw the heavy border lines, which

should be thicker than any other line on the drawing. The word "Plate" and its number should be printed at the top of the sheet, outside the border lines, and midway of its length, as shown. The student's name, followed by the words "Class" and "No.," and after this his course letter and *class number* should be printed in the lower right-hand corner below the border line, as shown. Thus, John Smith, Class No. C 4529. The date on which the drawing was completed should be placed in the lower left-hand corner, below the border line. *All of this lettering is to be in capitals $\frac{3}{32}''$ high.* Erase the division lines, and clean the drawing by rubbing very gently with the eraser. Care must be exercised when doing this, or the inked lines will also be erased It is best to use a so-called "Sponge Rubber" for this purpose, as it will not injure the inked lines. *If any part of a line has been erased or weakened, it must be redrawn.* Then write with the lead pencil your name and address in full on the back of your drawing, after which put your drawing in the empty tube which was sent you, and send it to the Schools.

HINTS FOR PLATE I.

35. *Do not forget to make a distinction between the width of the given and required lines, nor forget to make the construction lines dotted.*

When drawing dotted lines, take pains to have the dots and spaces uniform in length. Make the dots about $\frac{1}{16}''$ long and the spaces only about one-third the length of the dots.

Try to get the work accurate. The constructions must be accurate, and all lines or figures should be drawn of the length or size previously stated. To this end, work carefully and keep the pencil leads very sharp, so that the lines will be fine.

The lettering on the first few plates, as well as on the succeeding plates, is fully as important as the drawing, and should be done in the neatest possible manner. Drawings sent

in for correction with the lettering omitted will be returned for completion.

The reference letters like A, B, C, etc., as shown in Fig. 31, are not to be put on the plates.

Do not neglect to trim the plates to the required size. Do not punch large holes in the paper with the dividers or compasses. Remember that the division lines are to be erased—not inked in.

PLATE II.

36. Draw the division lines in the same manner as described for Plate I. The following five problems, Nos. 5 to 9, inclusive, are to be drawn in regular order, as was done in Plate I, with problems from 1 to 4. The letter headings are given in heavy-faced type after the problem number.

PROBLEM 5.—**To bisect a given angle.***

Case I.—*When the sides intersect within the limits of the drawing.* See Fig. 37.

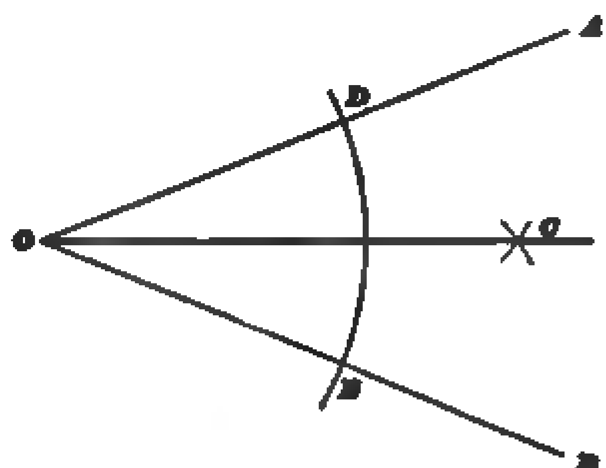

FIG. 37.

CONSTRUCTION.—Let $A\,O\,B$ be the angle to be bisected. Draw the sides $O\,A$ and $O\,B$ $3\frac{1}{4}''$ long. With the vertex O as a center, and any convenient radius, describe an arc $D\,E$ intersecting $O\,A$ at D and $O\,B$ at E. With D and E as centers, and a radius greater than the chord of half the arc $D\,E$, describe two arcs intersecting at C. The line drawn through C and O will bisect the angle; that is, $A\,O\,C = C\,O\,B$.

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* Since the letter heading in this problem is very short, it will be better to place it over each of the two cases separately, instead of running it over the division line, as was done with the long headings of the two cases in Plate I. Put Case I and Case II under the heading, as in the previous plate.

Case II.—*When the sides do not intersect within the limits of the drawing.* See Fig. 38.

Draw two lines, *A B* and *C D*, each $3\frac{1}{2}''$ long, and inclined towards each other as shown. With any point *E* on *C D* as a center, and any convenient radius, describe arc *F I G H*; with *G* as a center and same radius, describe arc *H L E F*, intersecting *F I G H* in *H* and *F*. With *L* as a center, and same radius, describe arc *K G J*; with *I* as a center, and same radius, describe arc *J E K*, intersecting *K G J* in *K* and *J*. Draw *H F* and *J K*; they intersect at *O*, a point on the bisecting line. With *O* as a center, and the

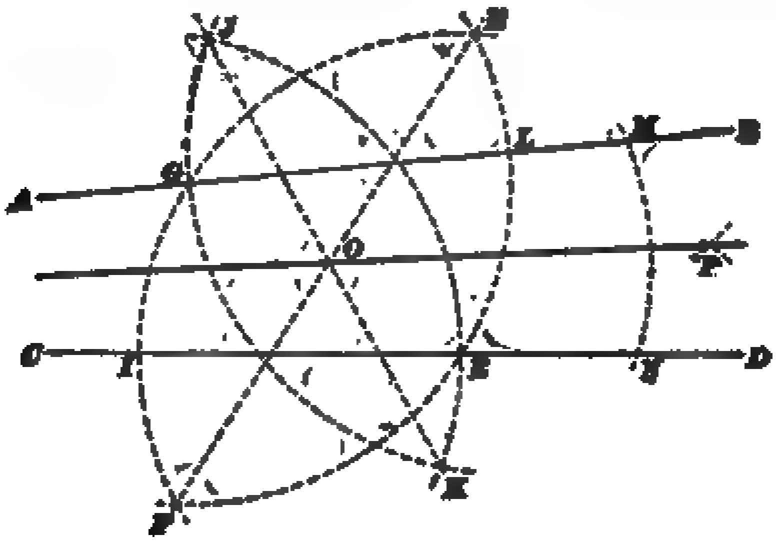

FIG. 38.

same or any convenient radius, describe an arc intersecting *A B* and *C D* in *M* and *N*. With *M* and *N* as centers, and any radius greater than one-half *M N*, describe arcs intersecting at *P*. A line drawn through *O* and *P* is the required bisecting line.

PROBLEM 6.—**To divide a given straight line into any required number of equal parts.**

See Fig. 39 (*a*).

CONSTRUCTION.—*A B* is the given line $3\frac{1}{16}''$ long. It is required to divide it into eight equal parts. Through one extremity *A* of the line, draw an indefinite straight line *A C*, making any angle with *A B*. Set the dividers to any

convenient distance, and space off eight equal divisions on AC, as AK, KI, IH, etc. Join C and B by the straight line CB, and through the points D, E, F, G, etc. draw lines DL, EM, etc. parallel to CB, by using the two triangles; these parallels intersect AB in the points L, M, N, etc., which are equally distant apart. The spaces LM, MN, NO, etc. are each equal to $\frac{1}{8}$ AB. Proceed in a similar way for any number of equal parts into which AB is to be divided.

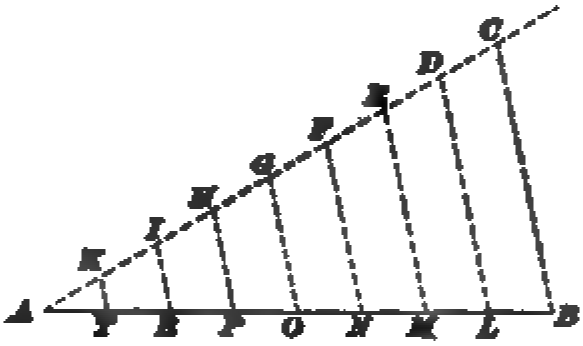

FIG. 39 (a).

An important modification of the method just described is shown in Fig. 39 (*b*). Draw AB as before, and erect the perpendicular BC. Now divide $3\frac{7}{16}''$, the length of AB, by 8, the number denoting the number of equal parts into which AB is to be divided, obtaining $3\frac{7}{16}'' \div 8 = \frac{3}{8}'' + \frac{7}{128}''$, dividing the whole number and the fraction separately. Now considering $\frac{3}{8}'' + \frac{7}{128}''$ to be approximately equal to $\frac{1}{2}''$, multiply $\frac{1}{2}''$ by 8, the number of parts into which AB is to be divided; the result is $\frac{1}{2}'' \times 8 = 4''$, which is the length of AC. With A as a center and a radius equal to $4''$ describe an arc cutting BC in C, and draw AC. Then with a scale lay off $AK = KI =$ etc. $= \frac{1}{2}''$, and project K, I, H, etc. upon AB, in T, R, P, etc., the required points. The advantage of this method over the other is that the T square and triangle can be used throughout, thus making it very much easier to draw the parallels DL, EM, etc.

FIG. 39 (b).

The student, when drawing this plate, is at liberty to use either of the two methods given in this problem.

PROBLEM 7.—**To draw a straight line through any given point on a given straight line to make any required angle with that line.**

CONSTRUCTION.—In Fig. 40, AB is the given line $3\frac{1}{2}''$ long, P is the given point, and EOF is the given angle.

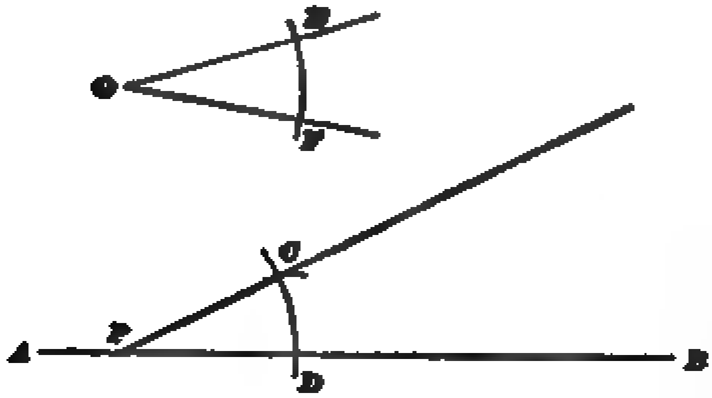

FIG. 40.

With the vertex O as a center, and any convenient radius, describe an arc EF cutting OE and OF in E and F. With P as a center, and the same radius, describe an arc CD. With D as a center, and a radius equal to the chord of the arc EF, describe an arc cutting CD in C. A line drawn through the points P and C will make an angle with AB equal to the angle O, or $CPD = EOF$.

PROBLEM 8.—**To draw an equilateral triangle, one side being given.**

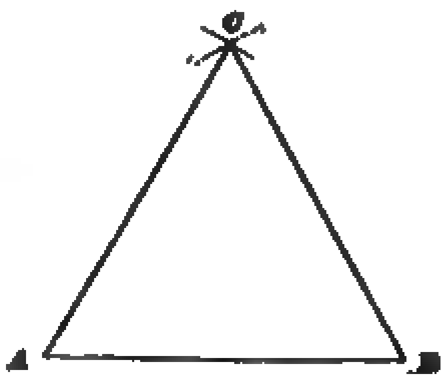

FIG. 41.

CONSTRUCTION.—In Fig. 41, AB is the given side $2\frac{1}{2}''$ long. With AB as a radius, and A and B as centers, describe two arcs intersecting in C. Draw CA and CB, and CAB is an equilateral triangle.

PROBLEM 9.—**The altitude of an equilateral triangle being given, to draw the triangle.**

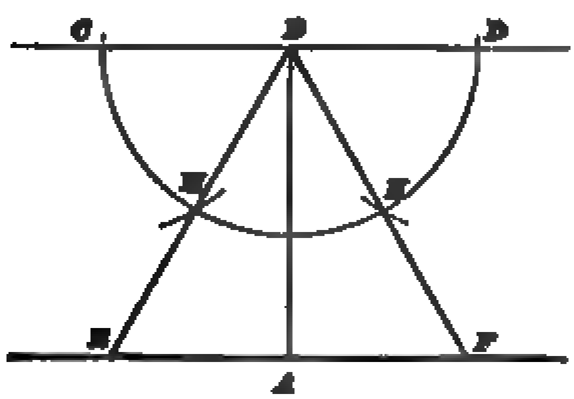

FIG. 42.

CONSTRUCTION.—In Fig. 42, AB is the altitude $2\frac{1}{4}''$ long. Through the extremities of AB draw the parallel lines CD and EF perpendicular to AB. With B as a center, and any convenient radius, describe the semicircle $CHKD$ intersecting CD in

C and *D*. With *C* and *D* as centers, and the same radius, describe arcs cutting the semicircle in *H* and *K*. Draw *B H* and *B K*, and prolong them to meet *E F* in *E* and *F*. *B E F* is the required equilateral triangle.

This problem finishes Plate II. The directions for inking in, lettering, etc. are the same as for Plate I.

PLATE III.

37. This plate is to be divided up like Plates I and II, and the six following problems are to be drawn in a similar manner:

PROBLEM 10.—**Two sides and the included angle of a triangle being given, to construct the triangle.**

CONSTRUCTION.—In Fig. 43, make the given sides *M N* $2\frac{1}{2}''$ long and *P Q* $1\frac{3}{4}''$ long. Let *O* be the given angle. Draw *A B*, and make it equal in length to *P Q*. Make the angle *C B A* equal to the given angle *O*, and make *C B* equal in length to the line *M N*. Draw *C A*, and *C A B* is the required triangle.

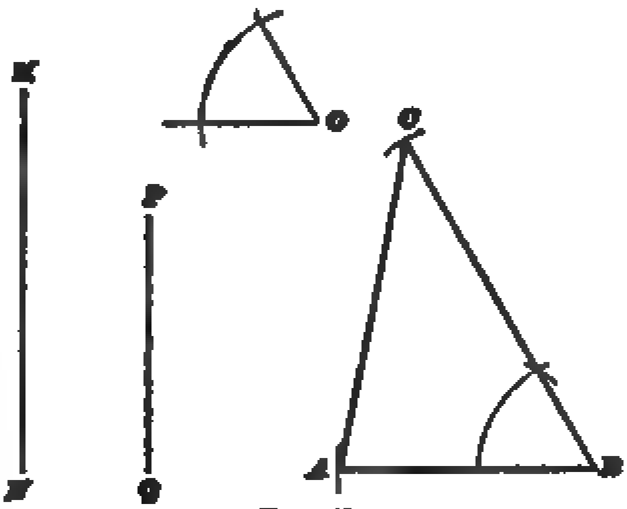

FIG. 43.

PROBLEM 11.—**To draw a parallelogram when the sides and one of the angles are given.**

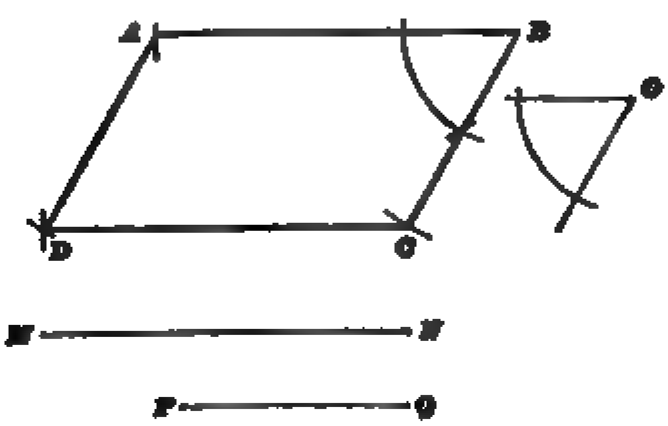

FIG. 44.

CONSTRUCTION. — In Fig. 44, make the given sides *M N* $2\frac{1}{2}''$ long and *P Q* $1\frac{3}{4}''$ long. Let *O* be the given angle. Draw *A B* equal to *M N*, and draw *B C*, making an angle with *A B* equal to the given angle *O*.

Make BC equal to PQ. With C as a center, and a radius equal to MN, describe an arc at D. With A as a center, and a radius equal to PQ, describe an arc intersecting the other arc in D. Draw AD and CD, and $ABCD$ is the required parallelogram.

PROBLEM 12.—**An arc and its radius being given, to find the center.**

CONSTRUCTION.—In Fig. 45, $ACDB$ is the arc, and MN, $1\frac{3}{4}''$ long, is the radius. With MN as a radius, and any point C in the given arc as a center, describe an arc at O. With any other point D in the given arc as a center, and the same radius, describe an arc intersecting the first in O. O is the required center.

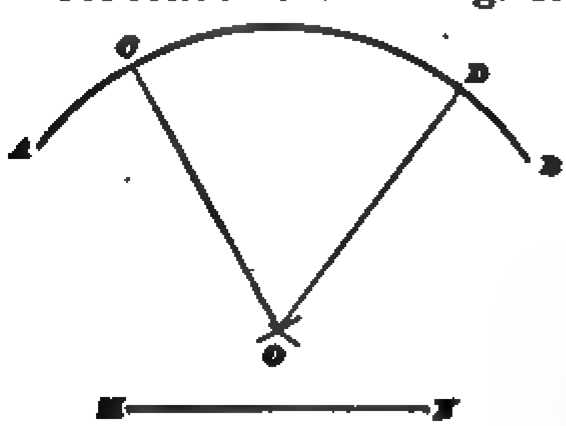

FIG. 45.

PROBLEM 13.—**To pass a circumference through any three points not in the same straight line.**

CONSTRUCTION.—In Fig. 46, A, B, and C are the given points. With A and B as centers, and any convenient radius, describe arcs intersecting each other in K and I. With B and C as centers, and any convenient radius, describe arcs intersecting each other in D and E. Through I and K and through D and E, draw lines intersecting at O. With O as a center, and OA as a radius, describe a circle; it will pass through A, B, and C.

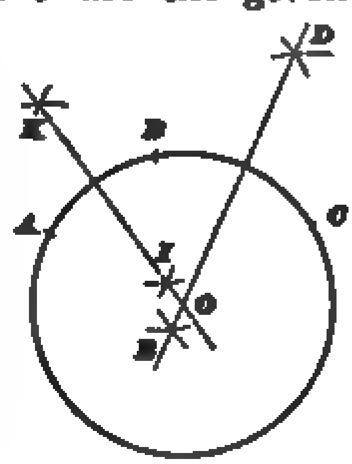

FIG. 46.

PROBLEM 14.—**To inscribe a square in a given circle.**

CONSTRUCTION.—In Fig. 47, the circle $ABCD$ is $3\frac{1}{2}''$ in diameter. Draw two diameters, AC and DB, at right angles to each other. Draw the lines AB, BC, CD, and DA joining the points of intersection of these diameters

with the circumference of the circle, and they will be the sides of the square.

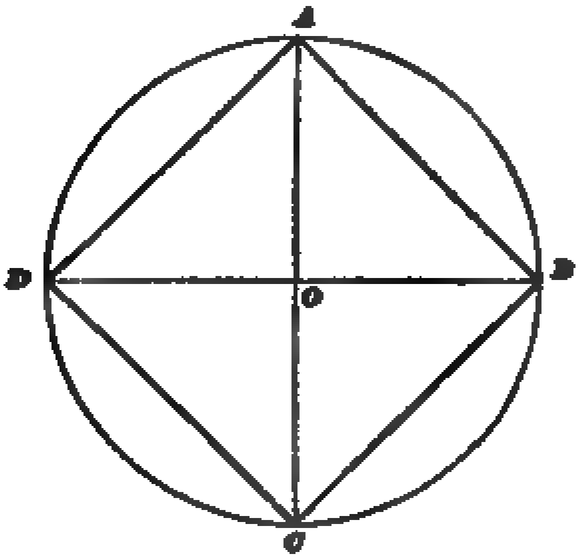

FIG. 47.

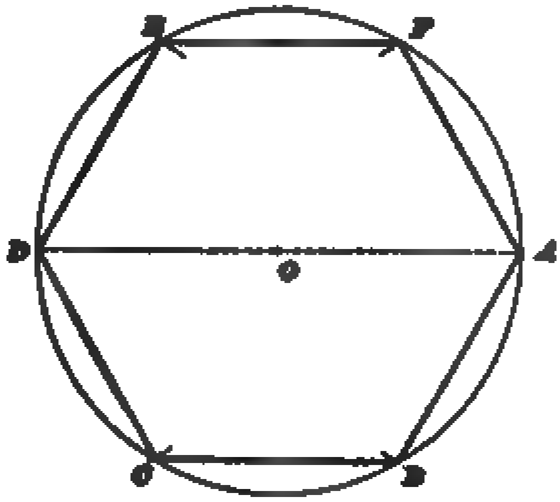

FIG. 48.

PROBLEM 15.—To inscribe a regular hexagon in a given circle.

CONSTRUCTION.—In Fig. 48, from O as a center, with the dividers set to $1\frac{3}{4}''$, describe the circle $A\,B\,C\,D\,E\,F$. Draw the diameter $D\,O\,A$, and from the points D and A, with the dividers set equal to the radius of the circle, describe arcs intersecting the circle at E, C, F, and B. Join these points by straight lines, and they will form the sides of the hexagon. This problem completes Plate III.

PLATE IV.

38. The first four problems on this plate are more difficult than any on the preceding plates and will require very careful construction. All the sides of each polygon must be of exactly the same length, so that they will space around evenly with the dividers. The figures should not be inked in until the pencil construction is done accurately. The preliminary directions for this plate are the same as for the preceding ones.

PROBLEM 16.—**To inscribe a regular pentagon in a given circle.**

CONSTRUCTION.—In Fig. 49, from O as a center, with the dividers set to $1\frac{3}{4}''$, describe the circle $A\,B\,C\,D$. Draw the two diameters $A\,C$ and $D\,B$ at right angles to each other. Bisect one of the radii, as $O\,B$, at I. With I as a center, and $I\,A$ as a radius, describe the arc $A\,J$ cutting $D\,O$ at J. With A as a center, and $A\,J$ as a radius, describe an arc $J\,H$ cutting the circumference at H. The chord $A\,H$ is one side of the pentagon.

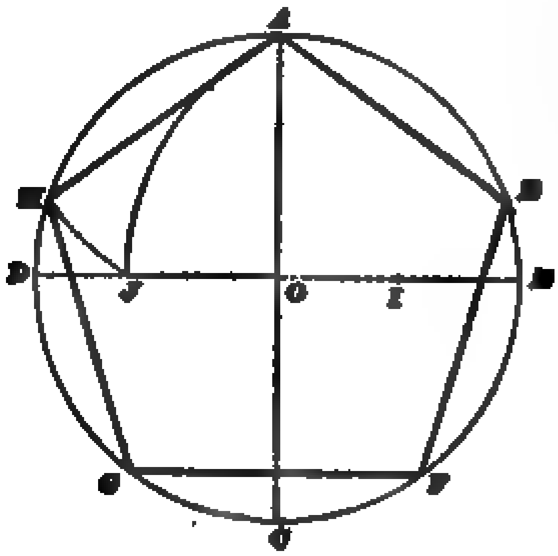
FIG. 49.

PROBLEM 17.—**To inscribe a regular octagon in a given circle.**

CONSTRUCTION.—In Fig. 50, from O as a center, with the dividers set to $1\frac{3}{4}''$, describe the circle $A\,B\,C\,D\,E\,F\,G\,H$. Draw the two diameters $A\,E$ and $G\,C$ at right angles to each other. Bisect one of the four equal arcs, as $A\,G$ at H, and draw the diameter $H\,O\,D$. Bisect another of the equal arcs, as $A\,C$ at B, and draw the diameter $B\,O\,F$. Straight lines drawn from A to B, from B to C, etc., will form the required octagon.

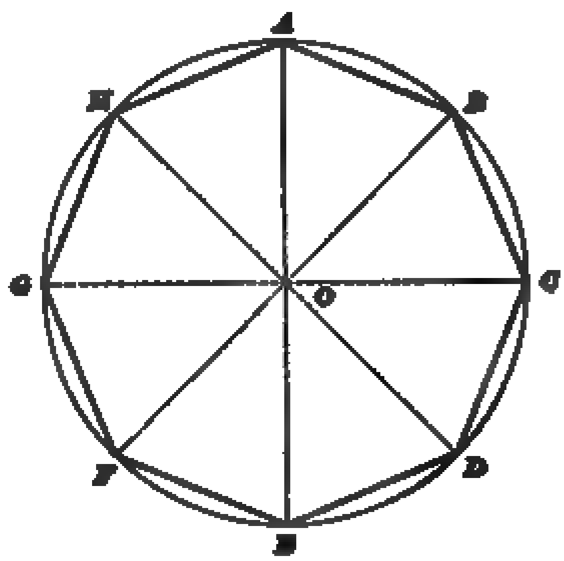
FIG. 50.

PROBLEM 18.—**To inscribe a regular polygon of any number of sides in a given circle.**

CONSTRUCTION.—In Fig. 51, from O as a center, with the

dividers set to 1¾″, describe the circle *A 7 C D*. Draw the two diameters *D 7* and *A C* at right angles to each other. Divide the diameter *D 7* into as many equal parts as the polygon has sides (in this case seven). Prolong the diameter *A C* and make *3′ A* equal to three-fourths of the radius *O A*. Through *3′* and *2*, the second division from *D* on the diameter *D 7*, draw the line *3′ I*, cutting the circumference at *I*. Draw the chord *D I*, and it is one side of the required polygon. The others may be spaced off around the circumference.

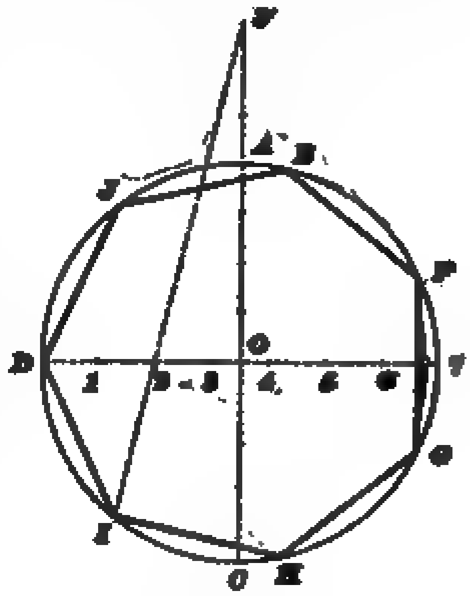

FIG. 51.

PROBLEM 19.—**The side of a regular polygon being given, to construct the polygon.**

CONSTRUCTION.—In Fig. 52, let *A C* be the given side. If the polygon is to have eight sides, the line *A C* should be, for this plate, 1¼″ long. Produce *A C* to *B*. From *C* as center, with a radius equal to *C A*, describe the semicircle *A 1 2 3 4 5 6 7 B*, and divide it into as many equal parts as there are sides in the required polygon (in this case eight). From the point *C*, and through the second division from *B*, as *6*, draw the straight line *C 6*. Bisect the lines *A C* and *C 6* by perpendiculars intersecting in *O*. From *O* as a center, and with *O C* as a radius, describe the circle *C A H G F E D 6*. From *C*, and through the points *1*, *2*, *3*, *4*, *5* in the semicircle, draw lines *C H*, *C G*, *C F*, etc. meeting the circumference. Joining the points *6* and *D*, *D* and *E*, *E* and *F*, etc. by straight lines, will complete the required polygon.

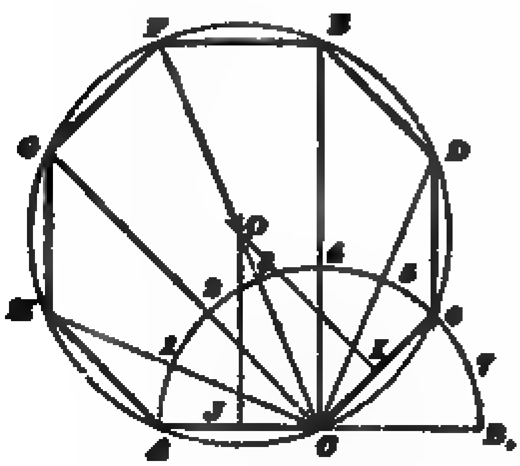

FIG. 52.

PROBLEM 20.—To find an arc of a circle having a known radius, which shall be equal in length to a given straight line.

NOTE.—There is no exact method, but the following approximate method is close enough for all practical purposes, when the required arc does not exceed ¼ of the circumference.

CONSTRUCTION.—In Fig. 53, let *A C* be the given line 3½″ long. At *A*, erect the perpendicular *A O*, and make it equal in length to the given radius, say 4″ long. With *O A* as a radius, and *O* as a center, describe the arc *A B E*. Divide *A C* into four equal parts, *A D* being the first of these parts, counting from *A*. With *D* as a center, and a radius *D C*, describe the arc *C B* intersecting *A B E* in *B*. The length of the arc *A B* very nearly equals the length of the straight line *A C*.

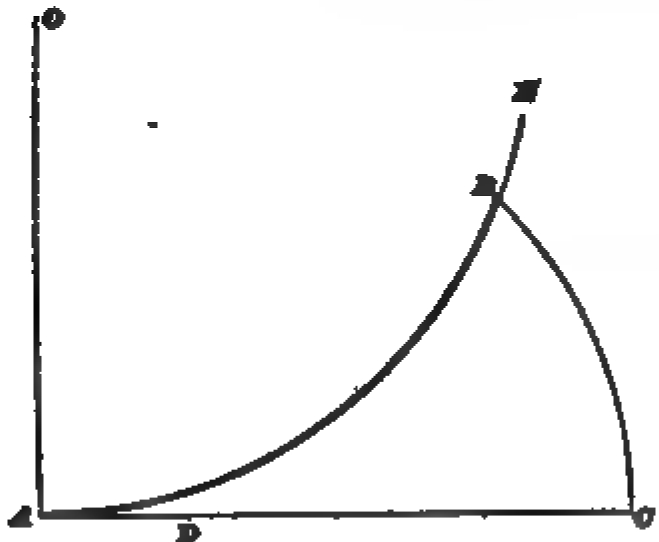

FIG. 53.

PROBLEM 21.—An arc of a circle being given, to find a straight line of the same length.

This is also an approximate method, but close enough for practical purposes, when the arc does not exceed ¼ of the circumference.

CONSTRUCTION.—In Fig. 54, let *A B* be the given arc; find the center *O* of the arc, and draw the radius *O A*. For this problem, choose the arc so that the radius will not exceed 1¾″. At *A*, draw *A C* perpendicular to the radius (and, of course, tangent to the arc).

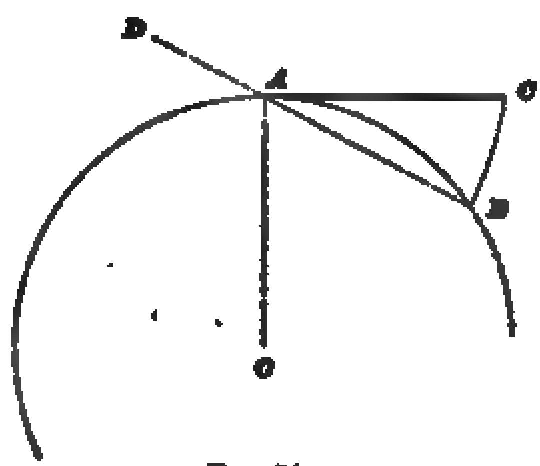

FIG. 54.

Draw the chord $A\,B$, and prolong it to D, so that $A\,D = \frac{1}{3}$ the chord $A\,B$. With D as a center, and a radius $D\,B$, describe the arc $B\,C$ cutting $A\,C$ in C. $A\,C$ will be very nearly equal to the arc $A\,B$.

PLATE V.

39. On this plate there are five problems instead of six. It should be divided into six equal parts or divisions, as the previous ones. The two right-hand end divisions are used to draw in the last figure of Plate V, which is too large to put in one division.

PROBLEM 22.—**To draw an egg-shaped oval.**

CONSTRUCTION.—In Fig. 55, on the diameter $A\,B$, which is $2\frac{1}{4}''$ long, describe a circle $A\,C\,B\,G$. Through the center O, draw $O\,C$ perpendicular to $A\,B$, cutting the circumference $A\,C\,B\,G$ in C. Draw the straight lines $B\,C\,F$ and $A\,C\,E$. With B and A as centers, and the diameter $A\,B$ as a radius, describe arcs terminating in D and H, the points of intersection with $B\,F$ and $A\,E$. With C as a center, and $C\,D$ as a radius, describe the arc $D\,H$. The curve $A\,D\,H\,B\,G$ is the required oval.

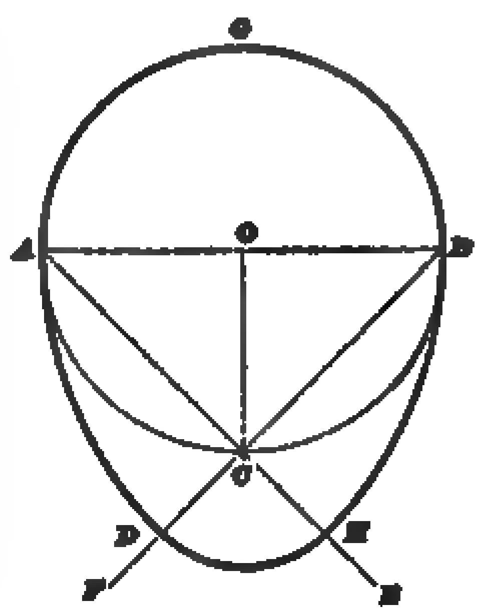

FIG. 55.

PROBLEM 23.—**To draw an ellipse, the diameters being given.** The exact method.

CONSTRUCTION.—In Fig. 56, let $B\,D$, the long diameter, or major axis, which is $3\frac{1}{2}''$ long, and $A\,C$, the short diameter, or minor axis, which is $2\frac{1}{4}''$ long, intersect at right angles to each other in the center O, so that $D\,O = O\,B$ and $A\,O = O\,C$. With O as a center, and $O\,C$ as a radius, describe a circle; with the same center, and $O\,D$ as a radius, describe another circle. Divide both circles into the same

number of equal parts, as *1–2*, *2–3*, etc. This is best done by first dividing the larger circle into the required number of parts, beginning at the center line *A C*, and then drawing radial lines through the points of division on this circle, to the center *O* of the circles, as shown in the upper right-hand quarter of the figure. The radial lines will divide the smaller circle into the same number of parts that the larger one has been divided into. Through the points of division on the smaller circle, draw horizontal lines, and, through the points of division on the larger circle, draw vertical lines; the points of intersection of these lines are points on the ellipse. Thus, the horizontal line *3 c* and the vertical line *3 c* intersecting at *c* give the point *c* of the ellipse. Trace a curve through the points thus found by placing an irregular curve on the drawing in such a manner that one of its bounding lines will pass through three or more points, judging with the eye whether the curve so traced bulges out too much or is too flat. Then adjust the curve again, so that its bounding line will pass through several more points, and so on, until the curve is completed. Care should be taken to make all changes in curvature as gradual as possible, and all curves drawn in this manner should be drawn in pencil before being inked in. It requires considerable practice to be able to draw a good curved line in this manner by means of an irregular curve, and the general appearance of a curve thus drawn depends a great deal upon the student's taste and the accuracy of his eye.

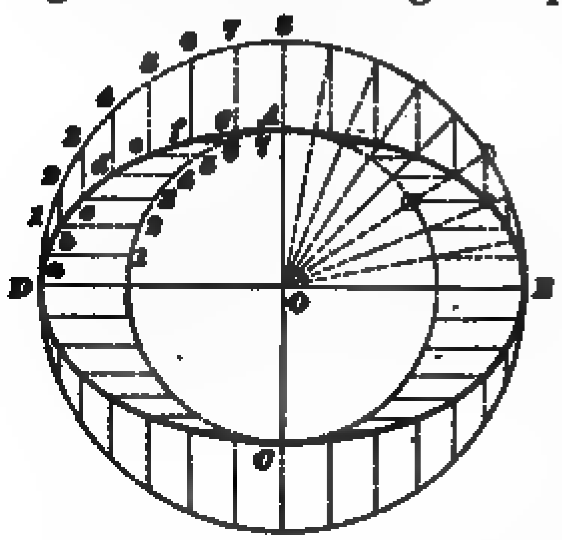

FIG. 36.

PROBLEM 24.—**To draw an ellipse by circular arcs.**

This is not a true ellipse, but is very convenient for many purposes.

CONSTRUCTION.—In Fig. 57, use the same dimensions as before. On the major axis AB, set off $Aa = CD$, the minor axis, and divide aB into three equal parts. With O as a center, and a radius equal to the length of two of these parts, describe arcs cutting AB in d and d'. Upon dd' as a side, construct two equilateral triangles dbd' and $db'd'$. With b as a center, and a radius equal to bD, describe the arc gDf intersecting bdf and $bd'g$ in f and g. With the same radius, and b' as a center, describe the arc cCe intersecting $b'd'c$ and $b'de$ in c and e. With A and B as centers, and a radius equal to the chord of the arcs Ac or Be, describe arcs cutting AB very near to d' and d. From the points of intersection of these arcs with AB as centers, and the same radius, describe the arcs cAg and eBf.

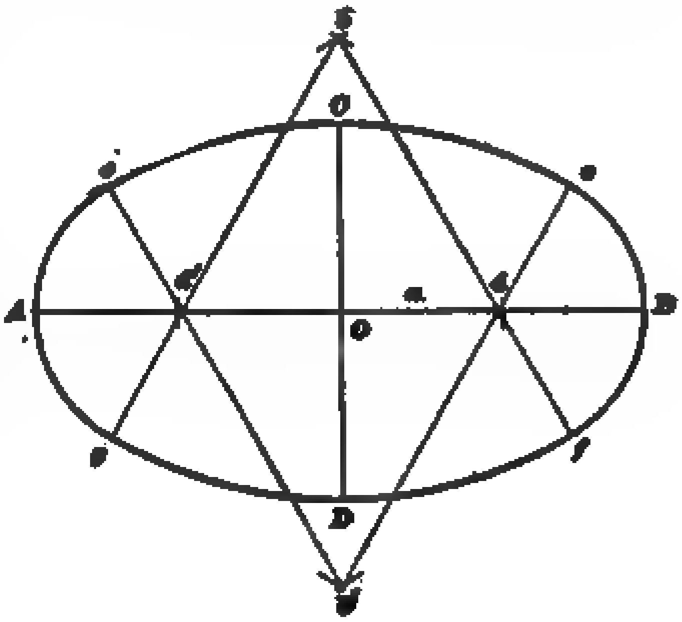

FIG. 57.

PROBLEM 25.—To draw a parabola, the axis and longest double ordinate being given.

EXPLANATION.—The curve shown in Fig. 58 is called a **parabola.** This curve and the ellipse are the bounding line of certain sections of a cone. The line OA, which bisects the area included between the curve and the line BC, is called the **axis.** Any line, BA or AC, drawn perpendicular to OA, and whose length is included between OA and the curve, is called an **ordinate.** Any line, as BC, both of whose extremities rest on the curve, and is perpendicular to the axis, is called a **double ordinate.** Point O is called the **vertex.**

CONSTRUCTION.—Make the axis OA equal to $3\frac{1}{2}''$, and the longest double ordinate BC equal to $3''$. BA, of course, equals AC. Draw DE through the other extremity of the

axis and perpendicular to it; also draw *B D* and *C E* parallel to *O A* and intersecting *D E* in *D* and *E*. Divide *D B* and *A B* into the same number of equal parts, as shown (in this case six); through the vertex *O*, draw *O 1*, *O 2*, etc. to the points of division on *D B*, and through the corresponding points *1*, *2*, etc., on *A B*, draw lines parallel to the axis. The points of intersection of these lines, *a*, *b*, *c*, etc., are points on the curve, through which it may be traced. In a similar manner, draw the lower half *O f g h i l C* of the curve.

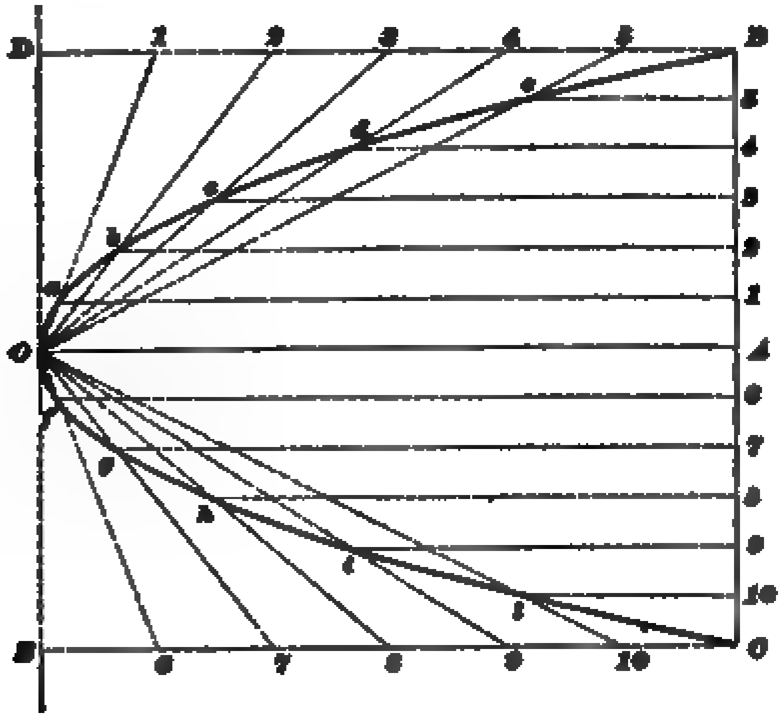

FIG. 58.

PROBLEM 26.—To draw a helix, the pitch and the diameter being given.

EXPLANATION.—The helix is a curve formed by a point moving around a cylinder and at the same time advancing along its length a certain distance; this forms the winding curved line shown in Fig. 59. The center line *A O*, drawn through the cylinder, is called the **axis** of the helix, and any line perpendicular to the axis and terminated by the helix is of the same length, being equal to the radius of the cylinder. The distance *B 12* that the point advances lengthwise during one revolution is called the **pitch**.

CONSTRUCTION.—As mentioned before, this figure occupies two spaces of the plate. The diameter of the cylinder is $3\frac{1}{2}''$, the pitch is $2''$, and a turn and a half of the helix is to be shown. The rectangle $FBED$ is a side view of the cylinder, and the circle $1'\,2'\,3'\,4'$, etc. is a bottom view. It will be noticed that one-half of a turn of the helix is shown

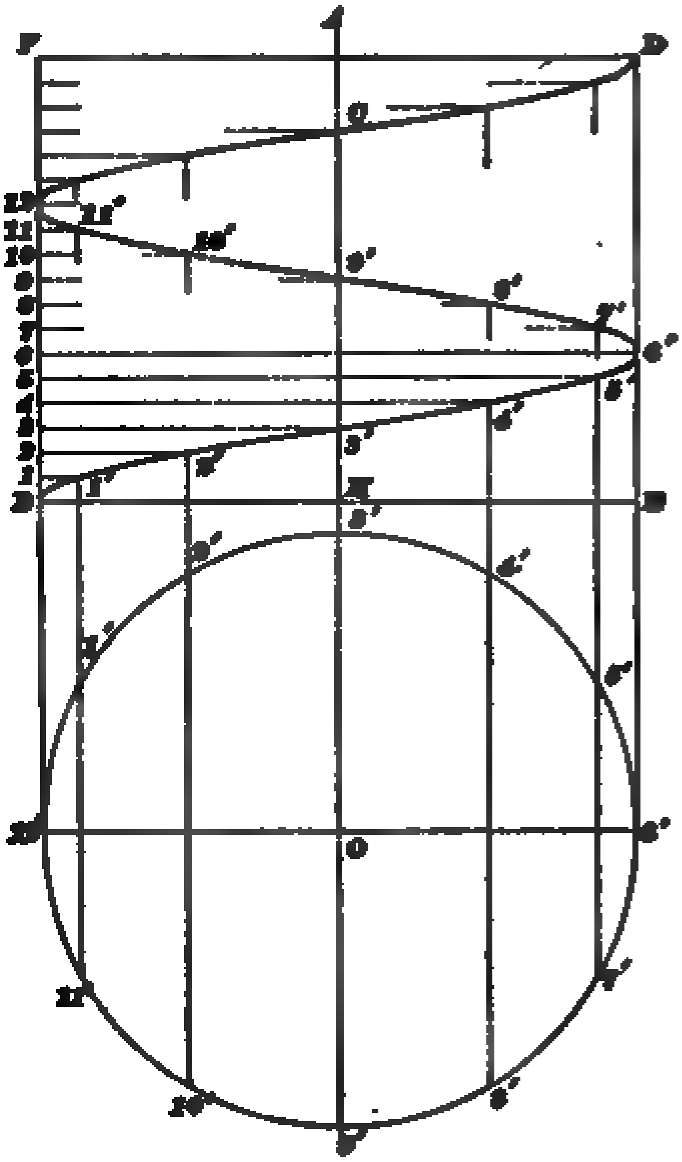

FIG. [illegible]

dotted; this is because that part of it is on the other side of the cylinder, and cannot be seen. Lines that are hidden are drawn dotted. Draw the axis $O\,A$ in the center of the space. Draw $F\,D$, $3\frac{1}{2}''$ long and $4''$ from the top border line; on it construct a rectangle whose height $F\,B = 3''$. Take the center O of the circle $2\frac{3}{4}''$ below the point H on the axis $A\,O$, and describe a circle having a diameter of $3\frac{1}{2}''$ equal to the

diameter of the cylinder. Lay off the pitch from *B* to *12* equal to 2″, and divide it into a convenient number of equal parts (in this case 12), and divide the circle into the same number of equal parts, beginning at one extremity of the diameter *12′ O 6′*, drawn parallel to *B E*. At the point *1′* on the circle divisions, erect *1′–1′* perpendicular to *B E*; through the point *1* of the pitch divisions, draw *1–1′* parallel to *B E*, intersecting the perpendicular in *1′*, which is a point on the helix. Through the point *2′*, erect a perpendicular *2′–2′*, intersecting *2–2′* in *2′*, which is another point on the helix. So proceed until the point *6* is reached; from here on, until the point *12* of the helix is reached, the curve will be dotted. It will be noticed that the points of division *7′*, *8′*, *9′*, *10′*, and *11′* on the circle are directly opposite the points *5′*, *4′*, *3′*, *2′*, and *1′*; hence, it was not necessary to draw the lower half of the circle, since the point *5′* could have been the starting point, and the operation could have been conducted backwards to find the points on the dotted upper half of the helix. The other full-curved line of the helix can be drawn in exactly the same manner as the first half.

This ends the subject of practical geometry. Mechanical drawing, or the representation of objects on plane surfaces, will now be commenced.

THE REPRESENTATION OF OBJECTS.

40. There are five kinds of lines used in mechanical drawing, thus:

The light full line.

The dotted line.

The broken and dotted line.

The broken line.

The heavy full line.

The light full line is used the most; it is used for drawing the outlines of figures, and all other parts that can be seen by the eye.

The dotted line, consisting of a series of very short dashes, is used in showing the position and shape of that part of the object represented by the drawing, which is concealed from the eye in the view shown; for example, a hollow prism closed on all sides. The hollow part cannot be seen; hence, its size, shape, and position are represented by dotted lines.

The broken and dotted line, consisting of a long dash, and two dots or very short dashes repeated regularly, is used to indicate the center lines of the figure or parts of the figure, and also to indicate where a section has been taken when a sectional view is shown. This line is sometimes used for construction lines in geometrical figures.

The broken line, consisting of a series of long dashes, is used in putting in the dimensions, and serves to prevent the dimension lines from being mistaken for lines of the drawing.

The heavy full lines are made not less than twice as thick as the light full lines, and are used for shade lines.

Further explanations in regard to these lines will be given when the necessity for using them arises.

41. The illustrations in this and the following paragraph should be carefully studied, but the student is not required to send in drawings from same. In Fig. 60 is shown a perspective view of a frustum of a pyramid having a rectangular base and a hole passing through the center of the frustum. This figure represents the frustum as it actually appears when the eye of the observer is in a certain position. The angles at A, B, C, and D are right angles, the hole is round, and the sides $A B$ and $D C$ are of equal lengths; so also

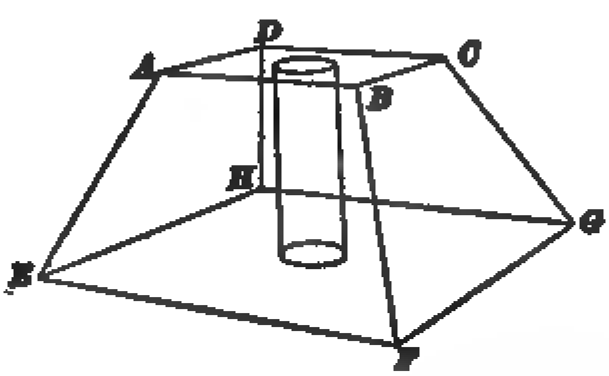

FIG. 60.

are $A\,D$ and $B\,C$; but, if they were measured on the drawing, it would be found that their lengths are all different. The same difficulty would be met with in trying to measure the angles and edges of the sides $A\,B\,F\,E$, $B\,F\,G\,C$, etc. The real lengths of any line could be found only by a person perfectly familiar with perspective drawing, and then only with great difficulty. Consequently, this method of representing objects is of no use to a patternmaker, carpenter, machinist, or engineer, except to show what the object looks like. In order to represent the object in such a manner that any line or angle can be measured directly, what is termed **projection drawing,** or *orthographic projection*, is universally employed. In the perspective drawing shown in Fig. 60, three sides of the frustum are shown, and the other three are hidden; in a projection drawing, but one side is usually shown, the other five being hidden.

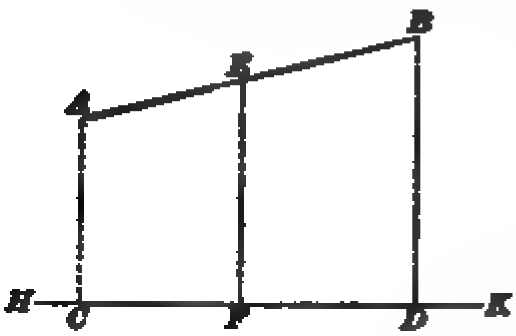

FIG. 61.

A line or surface is *projected* upon a plane, by drawing perpendicular lines from points on the line or surface to the plane, and joining them.

Thus, if perpendiculars be drawn from the extremities of a line, as $A\,B$, to another line $H\,K$, as shown in Fig. 61, that portion of $H\,K$ included between the feet of these perpendiculars is called the **projection** of $A\,B$ upon $H\,K$. Thus, $C\,D$ is the projection of $A\,B$ upon $H\,K$, the point C is the projection of the point A upon $H\,K$, and the point D is the projection of the point B upon $H\,K$.

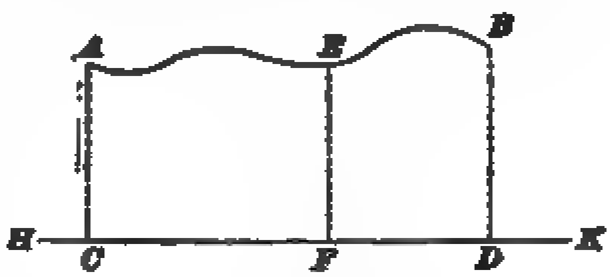

FIG. 62.

The projection of any point of $A\,B$, as E, can be found by drawing a perpendicular from E to $H\,K$, and the point where this perpendicular intersects $H\,K$ is its projection. In this case, the point F is the projection of the point E upon $H\,K$.

It makes no difference whether the line is straight or curved—the method of finding the projection is exactly the same. See Fig. 62.

In a similar way, a surface is projected upon a flat surface.

Thus, it is desired to project the irregular surface *a b d c*, Fig. 63, upon the flat surface *A B D C*. Draw the lines *a a'*, *b b'* perpendicular to the flat surface; join the points *a'* and *b'*, where these perpendiculars intersect the flat surface *A B D C*, by a straight line *a' b'*, and *a' b'* is the projection of the line *a b* upon *A B D C*.

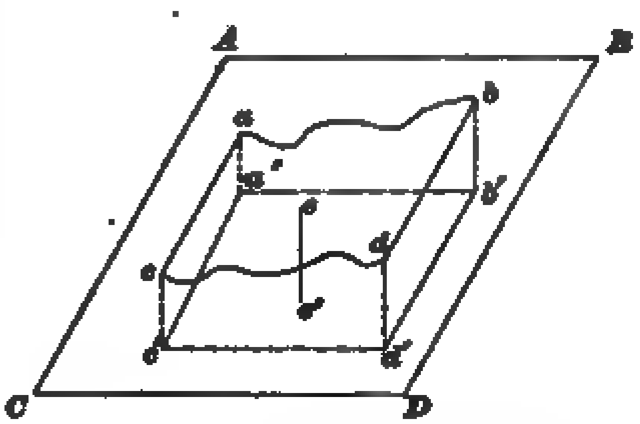

FIG. 63.

In the same way, *a' c'* is found to be the projection of *a c*; *c' d'*, the projection of *c d*; and *d' b'*, the projection of *d b*. Hence, the projection of the irregular surface *a b d c* upon the flat surface *A B D C* is the quadrilateral *a' b' d' c'*.

The projection of any point, as *e*, is found as before, by drawing a perpendicular from the point *e* to the surface; thus, *e'* is the projection of the point *e* upon the plane *A B D C*.

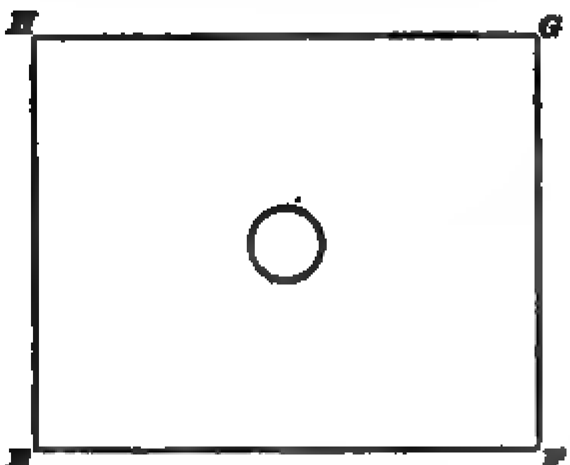

FIG. 64.

Suppose that the frustum, Fig. 60, were placed on a plane surface (a surface perfectly flat like a surface plate), and the outline of the bottom were traced by passing a pencil along its edges, including the round hole, the result would look like Fig. 64, in which the rectangle *E F G H* represents the bottom of the frustum and the circle represents the hole.

The angles and lengths of the sides are exactly the same as they are on the frustum itself; a similar drawing could be made to represent the top, but it is unnecessary, for the reason that the top can be projected on Fig. 64, and both objects

accomplished in one drawing. Fig. 65 illustrates the meaning of the last statement. Here $A'B'$ is the projection of the edge $A B$, Fig. 60; $B' C'$, of $B C$, etc. $A' E'$ is the projection of the edge $A E$; $B' F'$, of $B F$, etc. This drawing shows the figure as it would look if the eye were directly over it. A drawing which represents the object as if it were resting on a horizontal plane, and the observer looking at it from above, is called a **top view,** or **plan.** The line of vision is thus perpendicular to the faces $ABCD$ and $EFGH$ of the frustum.

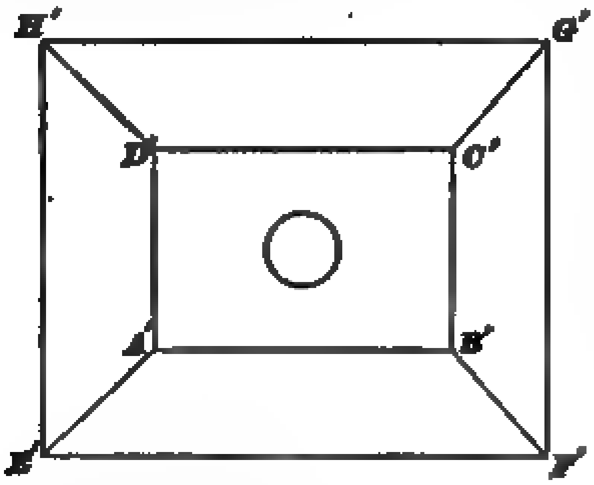

FIG. 65.

The lines $A B$, $B C$, etc., $E F$, $F G$, etc., and the diameter of the hole, can be measured directly. The drawing is not yet complete, since it does not show whether the ends and sides are rounding, hollowed out, or flat. For this purpose, two more views are necessary—*a vertical projection*, or *front view*, commonly called a **front elevation,** and a *side projection*, or **side view.** A front view (elevation) is drawn by imagining the eye to be so situated that the observer looks directly at the front of the object; in other words, the line of vision is parallel to the faces of the frustum. The side looked at is then drawn as if it were projected on a vertical plane at right angles to the horizontal plane, the vertical plane being also parallel to the edges $E F$ and $H G$ of the frustum shown in Fig. 60. The drawing would then look like Fig. 66. Here the trapezoid $ABFE$ represents the side $ABFE$ of the frustum; the altitude of the trapezoid being the same as the altitude of the frustum, it can be measured directly. The hole cannot be seen when the

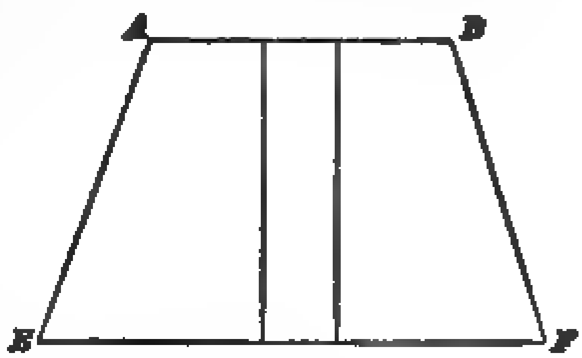

FIG. 66.

observer looks at the frustum in this position; hence, it is indicated by dotted lines. The projections of the lines AB and DC (also, of EF and HG, of AE and DH, and of BF and CG coincide.

To draw the side view (sometimes called a **side elevation**), imagine the frustum to be revolved around on its axis 90° to the left, and then draw it in precisely the same manner as the front elevation, by projecting the different lines upon a plane at right angles to the horizontal plane, and perpendicular to the edges EF and HG, that is, parallel to BC and FG. The side elevation would then be drawn as shown in Fig. 67. In this view the lines AD and BC (also, EH and FG, DH and CG, and AE and BF) coincide.

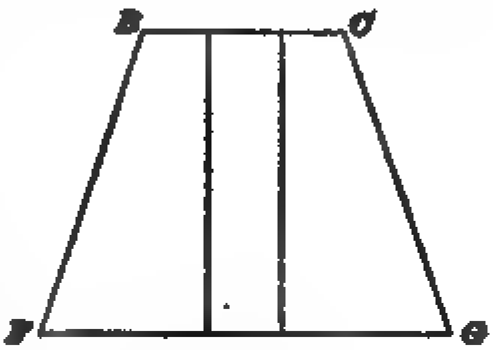

Fig. 67.

42. In order to show clearly the different views, and to guard against one view being mistaken for another, they are always arranged on the drawing in a certain fixed and invariable manner. Fig. 68 shows this method of arrangement. The plan is drawn first, then the two elevations. It is usually immaterial which of these views is drawn first, but the general arrangement is as shown. Any departure from this method of arrangement should be distinctly specified on the drawing in writing, unless the purpose of the draftsman is so clearly evident that no explanation is needed. The broken and dotted lines are the **center lines**; they serve to show the connection existing between the different views of the object, and to indicate axes of cylindrical surfaces of any kind. It will be noticed that, in the plan view, the two center lines cross each other at right angles, and that their point of intersection O is the center of the circle which represents the hole. Whenever a circle is drawn, two center lines should also be drawn through its center at right angles to each other; this enables any one looking at a drawing to

instantly locate the center of any circle. This remark also applies to ellipses, semicircles, etc.

To draw the frustum as shown in the last figure, either the front elevation or the plan is drawn first—whichever happens to be more convenient. Suppose the front elevation to be drawn first. Draw the vertical center line $m\,n$; measure the altitude of the frustum, and lay it off on this line, locating

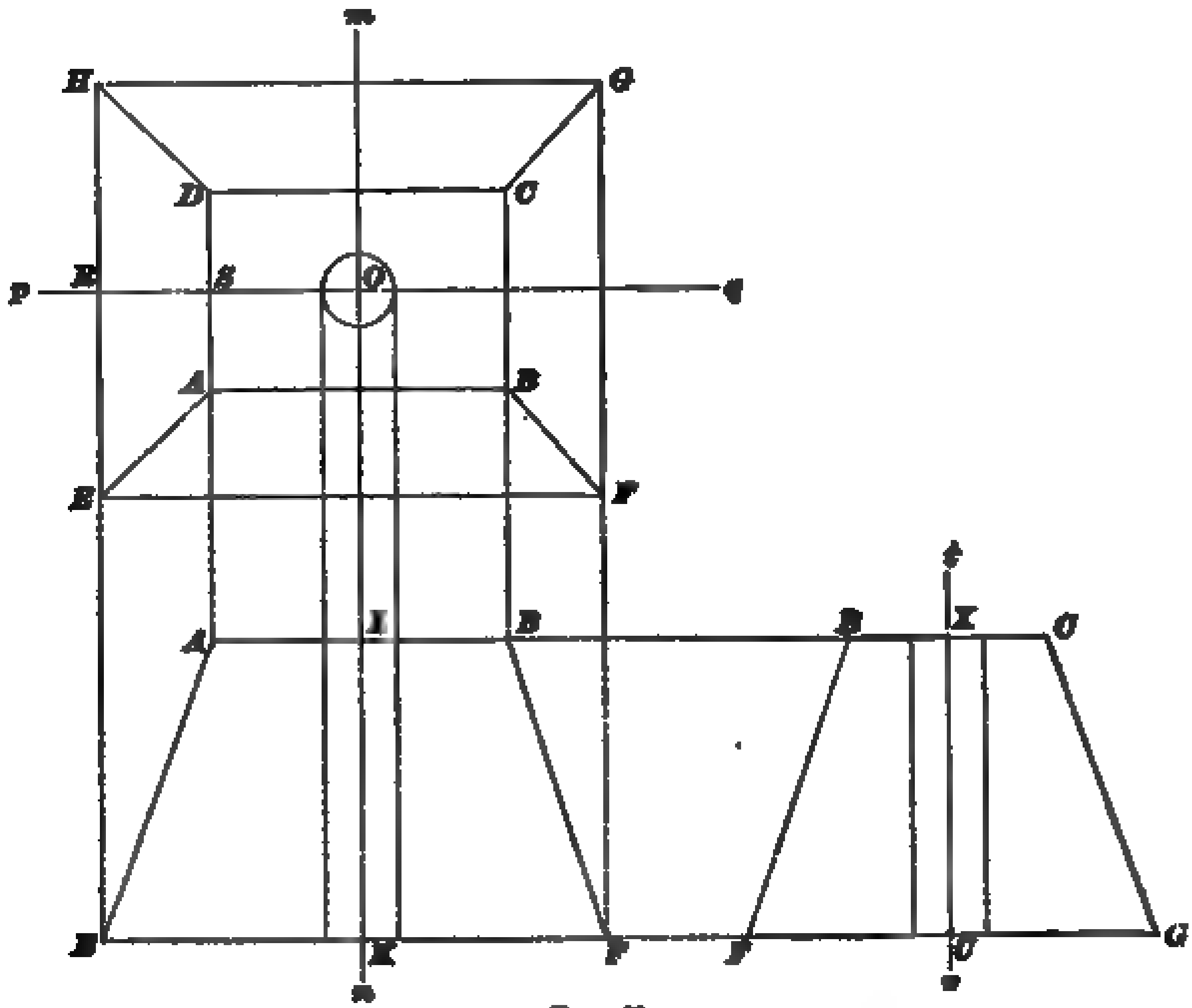

FIG. 68.

the points I and K; through these points, draw the lines $A\,B$ and $E\,F$ perpendicular to $m\,n$; make $A\,I = I\,B = \frac{1}{2}A\,B$, measured on the frustum; also $E\,K = K\,F = \frac{1}{2}E\,F$, measured on the frustum, and draw $A\,E$ and $B\,F$. Lay off the radius of the circular hole on both sides of the center line $m\,n$, and draw the dotted lines parallel to $m\,n$ through the extremities of these radii to represent the hole. The front elevation is now complete. To draw the plan, decide where the center is to be located on $m\,n$, and draw the horizontal

center line $p q$. With the point of intersection O of the two center lines as a center, and with a radius equal to the radius of the hole, describe a circle. Through the points A, B, E, and F, draw indefinite straight lines parallel to $m n$. On both sides of the center line $p q$, lay off on these lines $D S$ and $S A$, equal to $\frac{1}{2} D A$, and $H R$ and $R E$, equal to $\frac{1}{2} H E$, both $D A$ and $H E$ being measured on the frustum. Through the points H, E, D, and A, draw the lines $H G$, $E F$, $D C$, and $A B$, and join the points H and D, E and A, F and B, and G and C by straight lines, as shown. The figure thus drawn will be the plan.

To draw the side elevation, prolong the lines $A B$ and $E F$, and draw the center line $t v$. Lay off, on each side of $t v$, $F U$ and $U G$ equal to $\frac{1}{2} F G$, measured on the frustum, and $B X$ and $X C$ equal to $\frac{1}{2} B C$, measured on the frustum. Join B and F, and C and G, by the straight lines $B F$ and $C G$, and draw the hole dotted as in the front elevation. The drawing is now complete.

The student should have by this time a good idea of how simple objects may be represented by the different views of a drawing, and can now begin on the next plate.

DRAWING PLATE, TITLE: PROJECTIONS—I.

43. In making actual drawings of objects when the size of the plate is limited, it is usually impossible to divide it up into a certain number of parts, as in the case of the preceding plates, for the various figures differ widely in their sizes. These drawings should be so made that no part will come nearer than $\frac{3}{4}''$ to the border line, and the figures should be so arranged as to present a pleasing appearance to the eye, and not be scattered aimlessly all over the drawing.

Fig. 1 represents a **rectangular prism** $2''$ long, $1\frac{1}{2}''$ wide, and $\frac{3}{4}''$ thick. The prism is represented as if it were standing on one of its small ends, with the broad side towards the observer. The elevation $A B D C$ is drawn first; in this case, it will be a rectangle $2'' \times 1\frac{1}{2}''$. The top view, or plan,

F E B A, is next drawn; this is a rectangle $1\frac{1}{2}'' \times \frac{3}{4}''$, the side *A B* being the projection of the front of the prism, and the side *F E* of its back. Lastly, the side elevation is drawn; this is another rectangle *B E H D*, $2'' \times \frac{3}{4}''$, the side *B D* representing the projection of the front of the prism, and the side *B E* corresponding to the right-hand end *B E* of the plan.

Fig. 2 is a **wedge** standing on one of its triangular ends. It is the rectangle shown in Fig. 1, cut diagonally through the corner from *E* to *A* on the plan. It will be noticed that the two elevations are exactly the same as in Fig. 1, the plan showing the difference between the two figures.

Fig. 3 is another wedge, standing on one of its rectangular sides, formed by cutting through the prism, in Fig. 1, from *A* to *D*. The plan and side elevation are the same as in Fig. 1. Here, the front elevation shows the difference between Figs. 1 and 3. The point *D* of the elevation is projected on the plan in the point *D*, and the point opposite *D*, perpendicular to the plane of the paper, is the point *H*, shown in all of the side elevations.

Fig. 4 is also a wedge; it is formed by cutting through the prism in Fig. 1 from *B* to *H*. The front elevation and plan are the same as shown in Fig. 1, the side elevation being different. The point *H* in the side elevation opposite *D* is here projected in the point *H* of the plan; the point opposite *C* in the front elevation, and opposite *H* in the side elevation, is projected in the point *K* of the plan, the line *K H* being opposite *C D* in the plane of the base.

Fig. 5 shows a **cylinder** $1\frac{1}{4}''$ in diameter and $2''$ long. The side elevation is not given, since all elevations of a cylinder whose bases are perpendicular to its axis are the same. Either view may be drawn first, according to convenience.

Fig. 6 shows a **hexagonal prism** $2''$ long; the distance between any two parallel sides is $1\frac{1}{4}''$. In this case, the plan (a regular hexagon) must be drawn first. It is desired also that two of the parallel sides shall be horizontal. To draw the plan in this position, with the dimensions given, choose

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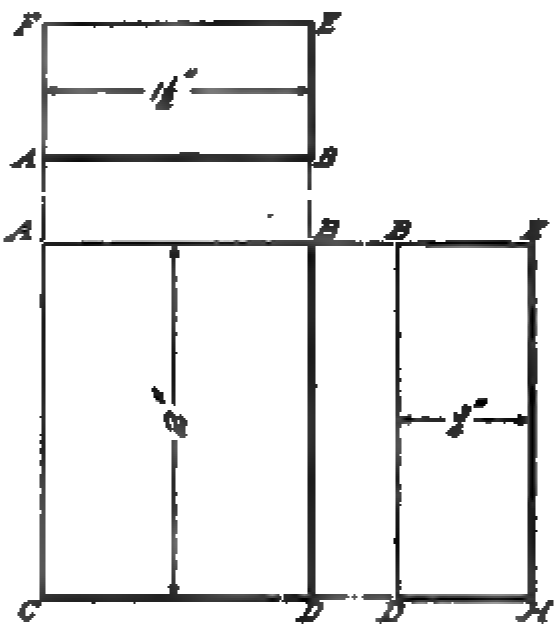


Fig.1.

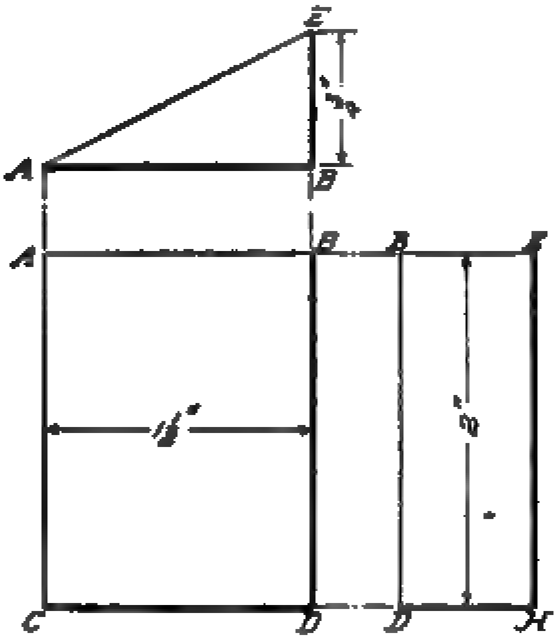


Fig.2.

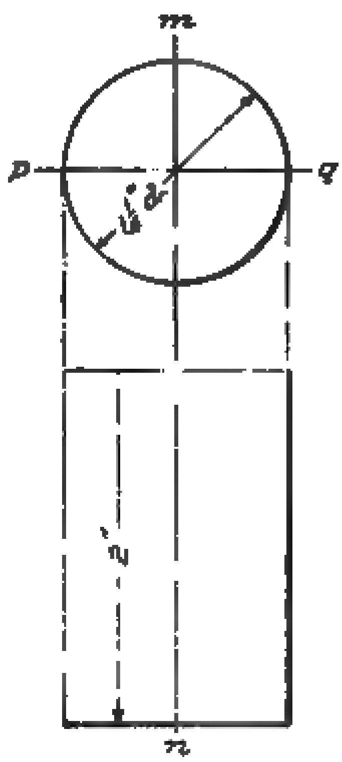


Fig. 5

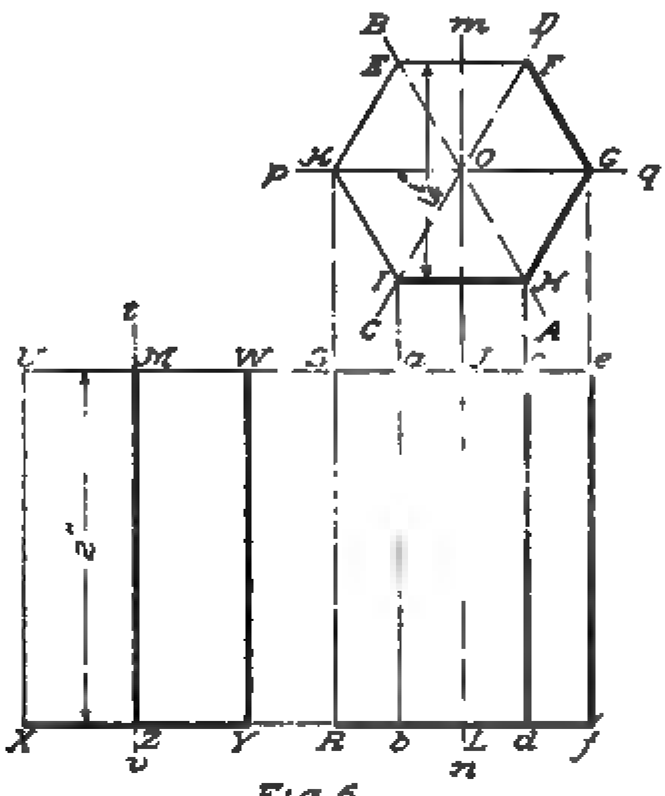
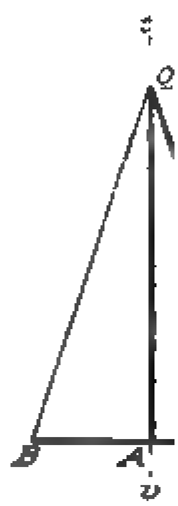


Fig. 6.



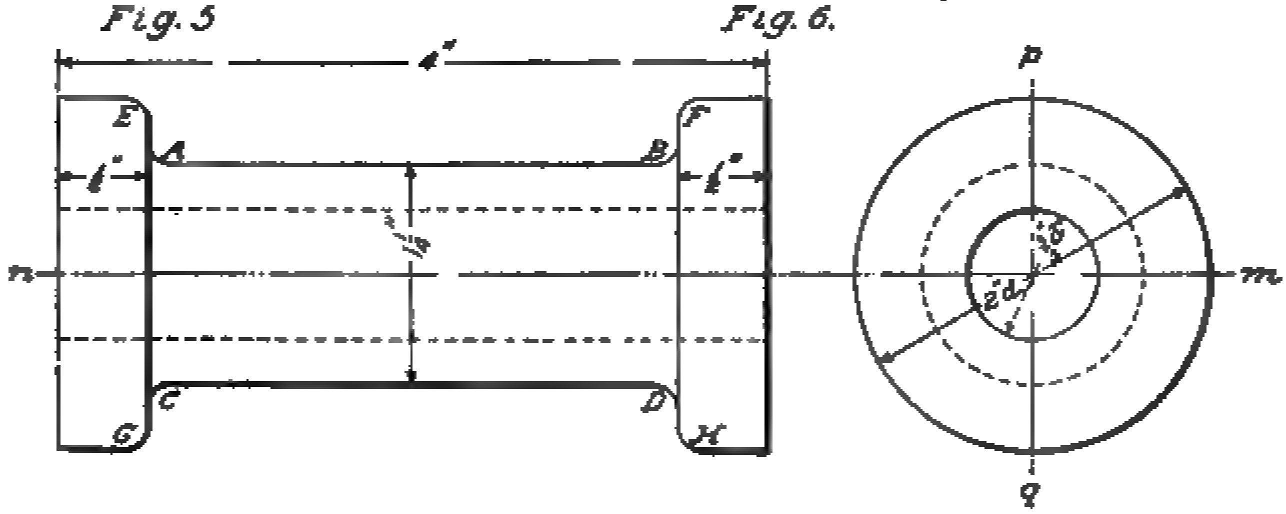


Fig. 10.

CTIONS—I.

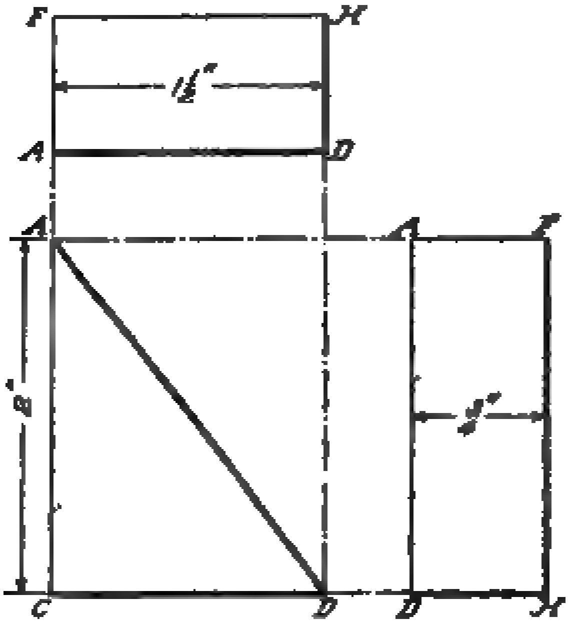


Fig. 3.

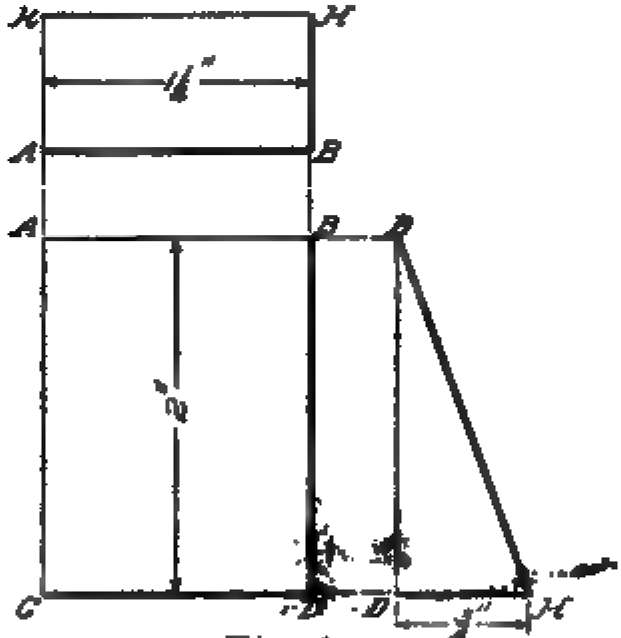


Fig. 4.

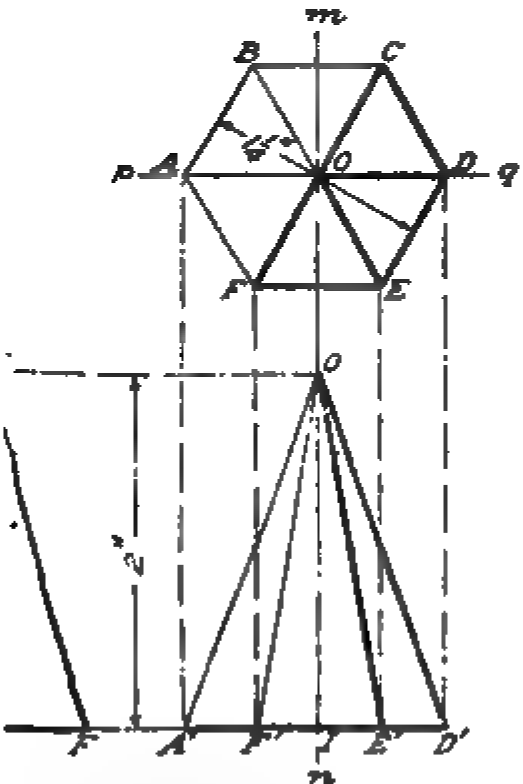


Fig. 7.

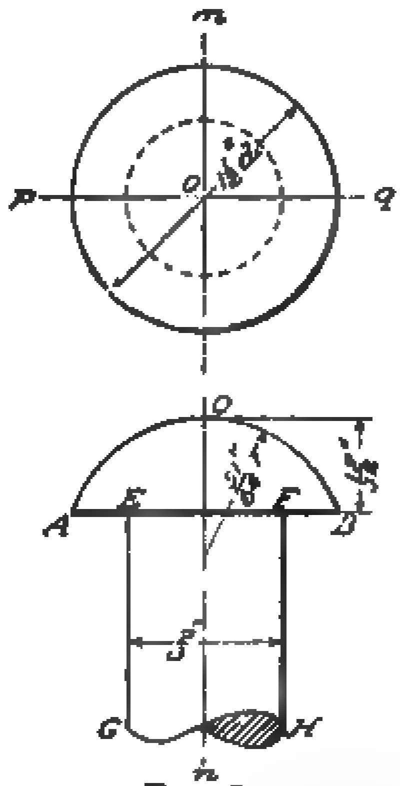


Fig. 8.

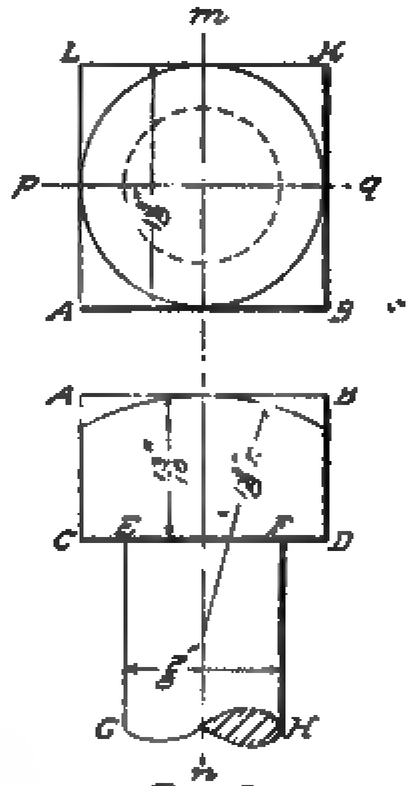


Fig. 9.

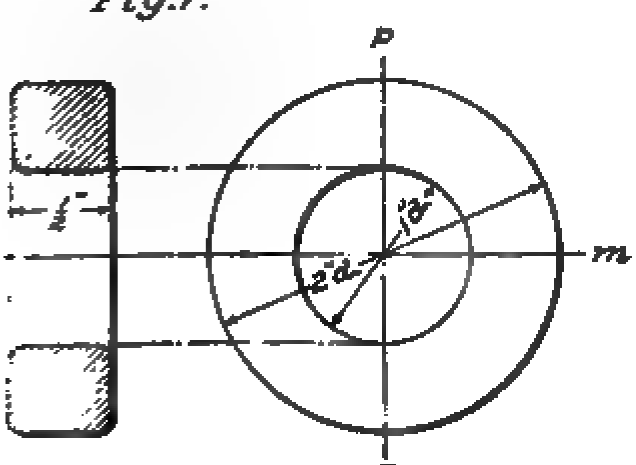


Fig. 11.

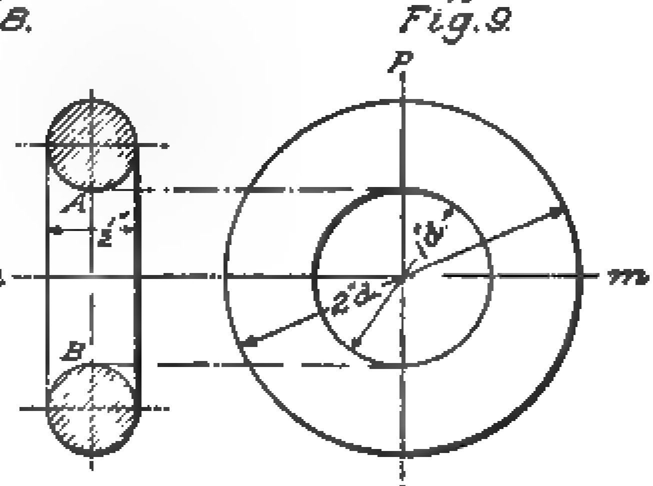


Fig. 12.

the center O of the hexagon; draw two center lines at right angles to each other, as $m n$ and $p q$. With O as a center, and a radius equal to one-half of the distance between two parallel sides ($1\frac{1}{4}'' \times \frac{1}{2} = \frac{5}{8}''$), describe a circle. Now, use the T square to draw two horizontal lines through the points of intersection of this circle with the center line $m n$. By means of the T square and 60° triangle, draw $A B$ and $C D$ through O, in such a manner that the angles $A O q$ and $C O p$ each equal 60°; this is done by keeping the longer of the two short sides of the triangle vertical, and passing the pencil along the hypotenuse. Through E and H, the points of intersection of $A B$ with the two parallel lines, draw $E K$ and $H G$ parallel to $C D$; and through F and I, the points of intersection of $C D$ with the two parallels, draw $F G$ and $K I$ parallel to $A B$. This completes the hexagon, and also the plan of the prism. To draw the front elevation, measure off, on the center line $m n$, the distance $J L$ equal to 2″, and through the points J and L draw the two horizontal lines $S e$ and $R f$. Project the points K, I, H, and G upon $S e$, as shown by the dotted lines; and, through the points of intersection of these dotted lines with $S e$, draw the vertical lines $S R$, $a b$, $c d$, and $e f$, thus completing the front elevation. To draw the side elevation, extend the lines $S e$ and $R f$, and draw the center line $t v$. Make $U W$ equal to $1\frac{1}{4}''$, which is equal to the distance between the parallel sides, and draw $U X$ and $W Y$; also, $M Z$, the point M corresponding to the point K of the plan.

Fig. 7 represents a **hexagonal pyramid**; the distance between two parallel sides of the base is $1\frac{1}{4}''$, and the altitude is 2″. As in Fig. 6, the plan must be drawn first. Then, to draw the front elevation, lay off $O I$ on the center line $m n$ equal to the altitude, and through I draw the base line $A' D'$. Project the points D, E, etc. of the plan upon $A' D'$, as shown by the dotted lines, and join them with the point O by the straight lines $A' O$, $F' O$, $E' O$, and $D' O$; these lines are the vertical projections of the edges of the pyramid; the horizontal projections of the edges are $F O$, $E O$, $D O$, etc. The side elevation can be easily drawn, and does not

require a special description, the length of the base BF being equal to the distance between the parallel sides, or $1\frac{1}{4}''$.

Fig. 8 shows a **rivet**, $\frac{7}{8}''$ in diameter, having a button head $1\frac{1}{4}''$ in diameter. The side elevation is not given, since it is exactly the same as the front elevation. Either of the two views may be drawn first, according to convenience. Suppose that the elevation is first drawn. Draw the center line $m\,n$, and the line $A\,B$ for the base of the head. On the center line lay off from the line $A\,B$, or the base of the head, a point O, at a distance of $\frac{19}{32}''$, the height of the head. With the compasses set to a radius of $\frac{31}{32}''$, and from a point on the center line $m\,n$, describe an arc $A\,O\,B$, taking care to pass this arc through the point O. Lay off from, and on both sides of, the center line $m\,n$ a distance of $\frac{7}{16}''$, or $\frac{1}{2}$ of the diameter of the rivet, and draw $E\,G$ and $F\,H$. Draw the other center line $p\,q$ of the plan, and, with O as a center, and a radius equal to the radius of the button head, describe a circle. With the same center, and a radius equal to $\frac{7}{16}''$, describe the dotted circle, the horizontal projection of the rivet. The irregular line $G\,H$ indicates that only a part of the rivet is shown. This is done so as not to take up too much space on the drawing.

Fig. 9 shows an ordinary **square-headed bolt** $\frac{7}{8}''$ in diameter, having a head $1\frac{3}{8}''$ square and $\frac{13}{16}''$ thick. Draw the center lines $m\,n$ and $p\,q$. Construct the rectangle $A\,B\,D\,C$, $1\frac{3}{8}'' \times \frac{13}{16}''$, the elevation of the head. Locate the points E and F at a distance of $\frac{7}{16}''$ from each side of the center line, and draw $E\,G$ and $F\,H$. With the compasses set to a radius of $1\frac{3}{8}''$ and from a point on the center line $m\,n$, describe the arc representing the chamfering of the head. Draw the plan of the head $L\,K\,B\,A$ (a square whose edge measures $1\frac{3}{8}''$), and the dotted circle $\frac{7}{8}''$ in diameter, the projection of the body of the bolt, which cannot be seen in this view.

Fig. 10 shows a **distance piece** used to separate two other parts, and to keep them a certain distance apart. The arrangement of the views of this figure is somewhat different from the preceding ones, in order to make room for it on the drawing. Draw the center line $n\,m$, and construct

the figure according to the dimensions marked on the plate. Use a radius of $\frac{1}{8}''$ for the fillets at A, B, C, and D, and an equal radius to round the corners at E, F, G, and H.

Fig. 11 shows a **square cast-iron washer.** Instead of making an elevation and plan as usual, a section is taken through $p\,q$; that is, the washer is imagined to be cut on the line $p\,q$, with all that part of the figure to the left of $p\,q$ removed, and an elevation drawn of the remaining part. In order to distinguish a sectional drawing without any possibility of mistake, the so-called section lines are employed. These are usually drawn by laying a 45° triangle against the edge of the T square, and drawing a series of parallel lines as nearly equally distant apart as can be judged by the eye. For cast iron, these lines are full, thin lines, all of the same thickness, and must not be drawn too near together. The method of sectioning for other materials will be given later on. It is not usual to draw the section lines in pencil, but to wait until the outlines of the drawing have been inked in, and then section directly with the drawing pen. The shortest distance apart of the section lines should rarely be *less* than $\frac{1}{16}''$, unless the drawing is of such small dimensions as to cause a sectioning of this width to look coarse. This is the case with Figs. 11 and 12 of this plate. In these two figures make the section lines a full $\frac{1}{32}''$ apart. Only that part of the figure is sectioned which is touched by the cutting plane, the rest of the figure being drawn as if it were projected upon the cutting plane. The corners of this figure should be rounded with a radius of $\frac{1}{16}''$; the other dimensions can be obtained from the plate.

Fig. 12 is a **cast-iron cylindrical ring.** It is shown in plan and section. The dimensions given suffice for the drawing of the figure without further explanations. The inner circle of plan is the projection of the innermost points of the ring which form a circle whose diameter is $A\,B$.

44. When inking in a drawing, it is generally best to draw the circles and other curved lines first, and the straight lines afterwards. This enables the draftsman to easily blend

into one line the straight lines meeting the curves, so that their points of meeting cannot be detected; it enables the tangent lines to be drawn with better success, and also shortens the time of inking in a drawing. It will be noticed that some of the straight lines are heavy and some light, and that parts of the full-line circles are heavy and the rest of the circle light. These are the shade lines; they are described later on. The student may make all of the full lines, except the border lines of this plate and the three following plates, of the same thickness, if he so desires. The dotted lines used to indicate those parts of the figures that are hidden must be of the same thickness as full lines, while the construction lines and center lines should be very thin.

45. Dimensions.—The dimension lines and figures on this and succeeding plates are to be inked in by the student. Make the dimension figures $\frac{3}{32}''$ high, and of the same style as those shown in Art. **20.** Fractions should be $\frac{1}{8}''$ high over all. If there is not room for figures of this size, great care should be taken to make them *clear.*

Until after the student has obtained sufficient practice in lettering, he should draw guide lines in pencil for the dimension figures, as in Fig. 69, unless he can make them look well without. All the figures should have the same slant of 60°, and, when printing fractional dimensions, the *whole* fraction should have the same slant as the figures; that is, the denominator should be under the numerator in a *slanting* direction, and not straight below it. Make the dividing line between the numerator and denominator horizontal, not slanting.

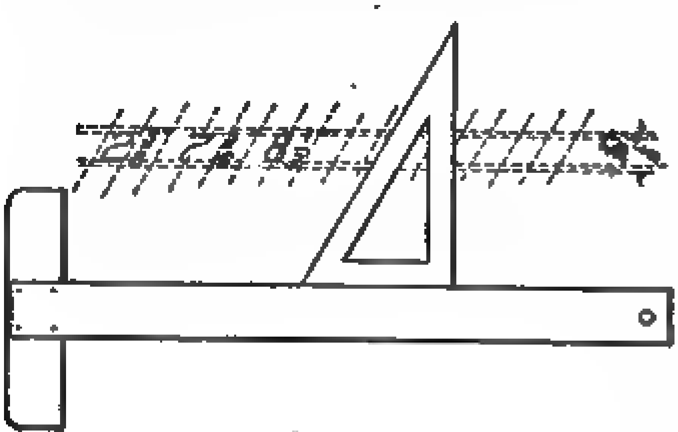


FIG. 69.

Dimension and extension lines must be light, broken lines

of the same thickness as the center and construction lines. Care should be exercised to make the arrowheads as neatly as possible and of a uniform size. They are made with a Gillott's No. 303 pen, and their points must touch the extension lines, as illustrated in Fig. 70. Do not make arrowheads too flaring.

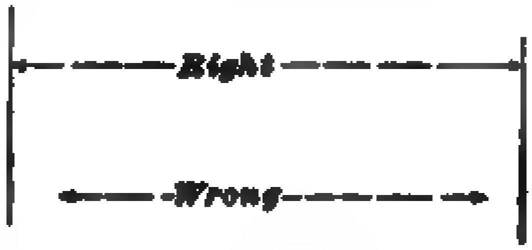


FIG. 70.

When putting in the dimensions, care should be taken to give *all* that would be needed to make the piece which the drawing represents, but do not repeat the same dimension on different views. Thus, in Fig. 1 of this plate, the length is given in the front elevation as 2″, and it is obviously unnecessary to give the same dimension in the side elevation. Again, the dimension lines should be put where they would be most likely to be looked for. In Fig. 10 of this plate, the diameter of the central part of the distance piece is marked $1\frac{1}{4}''$ in the elevation; it could have been marked on the side elevation, as the diameter of the dotted circle, but a person wishing to find the size of this part of the piece would naturally look for it in the front elevation. This is also true of the diameter of the flange. The diameter of the hole could be on the plan or elevation, but it is put on the plan because it is denoted there by a full line, while in the elevation the hole is dotted. Never cross one dimension line by another, if it can well be avoided. Thus, in Figs. 2 and 4 of this plate, the bounding lines of the triangular views are extended by fine broken lines, in order that the dimension lines ($\frac{3}{4}''$) may not cross the lines marking the length and width of the wedge.

The student should ink in all of the figures used for dimensions shown on this and succeeding plates, on his drawing, but should omit the letters used to describe the different objects. The titles should be made in block letters as shown on sample copies. The date, name, course letter, and class number are to be put on as in the preceding plates.

DRAWING PLATE, TITLE: PROJECTIONS—II.

46. The figures on the last plate were drawn under the supposition that the center lines, and at least one flat side, were parallel to the plane of the paper; the center lines were also either vertical or horizontal. This is always possible in detail drawings, where each piece is drawn separately by itself, but in the case of machines, where the parts are placed at different angles, they cannot always be drawn in this manner. The figures on this plate are so drawn that they show objects similar to those in the last plate, but at different angles. The student should exercise particular care to understand this plate and the two succeeding ones; if he thoroughly masters them, he should experience no great difficulty in the plates that follow.

Fig. 1 shows a **rectangular prism** $2\frac{1}{2}''$ long, $2''$ wide, and $1''$ thick, standing in a perpendicular position on one of its small ends in such a manner that the broad sides make an angle of 30° with a horizontal line. Draw the plan first. To do this, construct the rectangle $A\,B\,C\,D$ $2'' \times 1''$, with the parallel edges $A\,B$ and $D\,C$ making an angle of 30° with the horizontal; this may be done by holding the head of the T square against the left-hand end of the board, and using the 60° triangle. To construct the front elevation, draw a horizontal line $A'\,C'$, and project A upon this line, thus obtaining the point A'. Draw $A'\,E$ perpendicular to $A'\,C'$, and make it equal in length to $2\frac{1}{2}''$, the length of the prism. Through E draw $E\,G$. Project the points B and C upon $A'\,C'$, and draw $B'\,F$ and $C'\,G$. The back edge $D'\,H$ of the prism is not seen, and, hence, its position is indicated by the dotted line $D'\,H$.

The side elevation can be drawn in a similar manner by projecting the points $A\,B\,C\,D$ upon a vertical line, as $I\,L$. Produce $A'\,C'$ and $E\,G$, and make $B'\,D'$ equal to $I\,L$. Now use the spacing dividers, and set off $B'\,C'$ equal to $I\,C$, and $B'\,A'$ equal to $I\,K$. Through B', C', A', and D', draw the vertical lines $B'\,F$, $C'\,G$, $A'\,E$, and $D'\,H$, drawing $A'\,E$ dotted, because, when looking at the prism in the direction of the arrow, the edge $A'\,E$ is not seen.

PROJEC

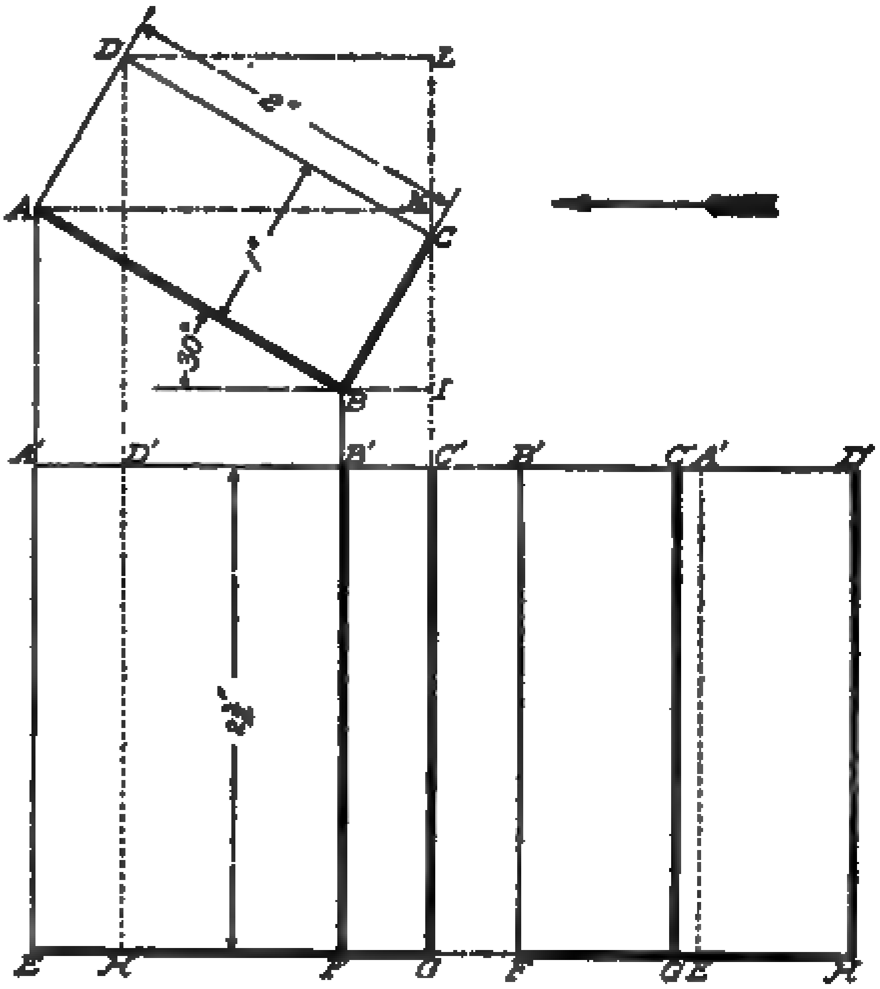
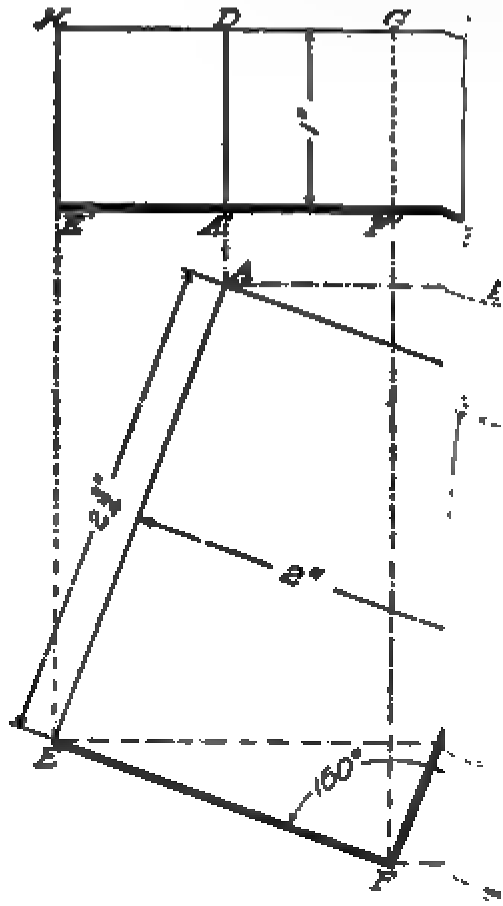


Fig. 1.



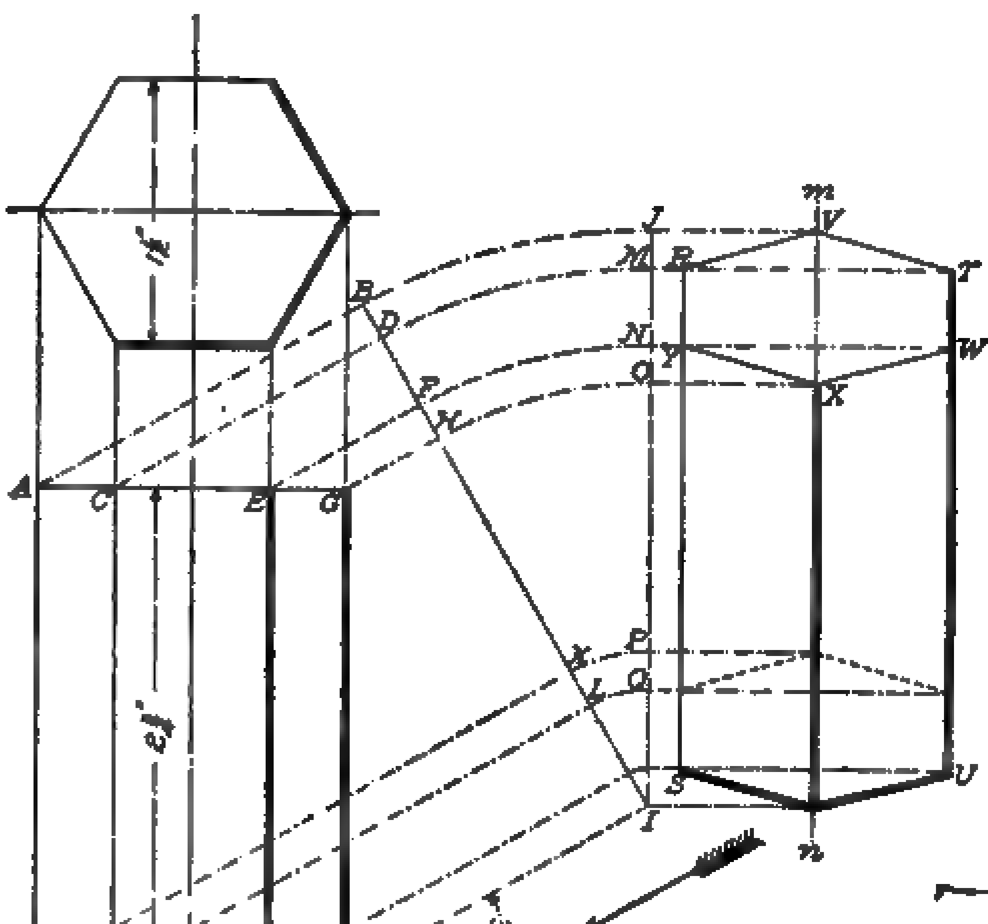


Fig. 4.

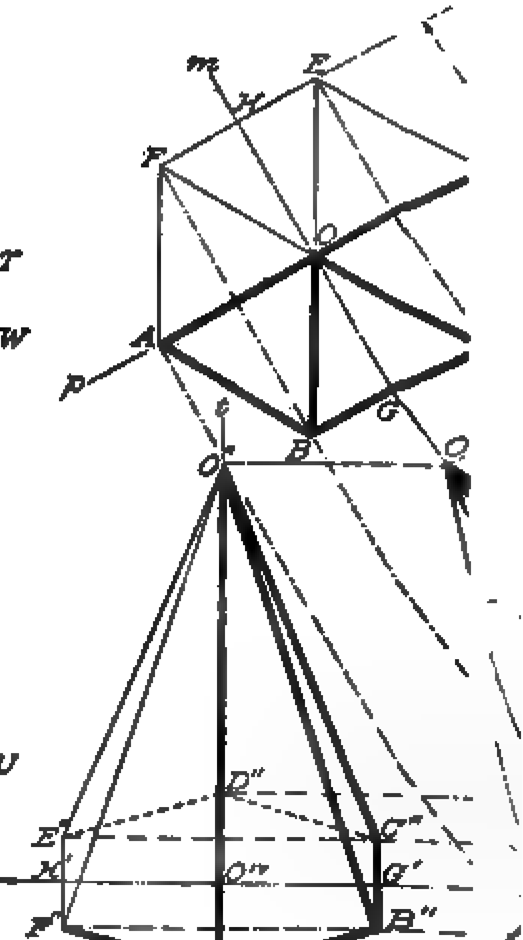
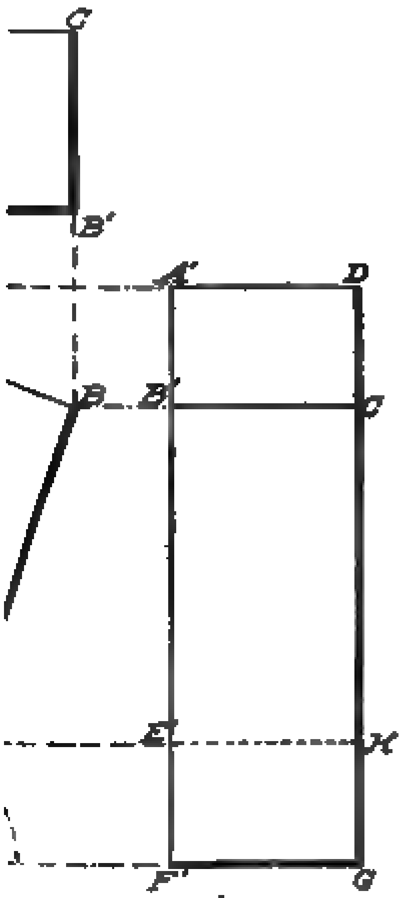


Fig. 5.

IONS-II.



...g 2.

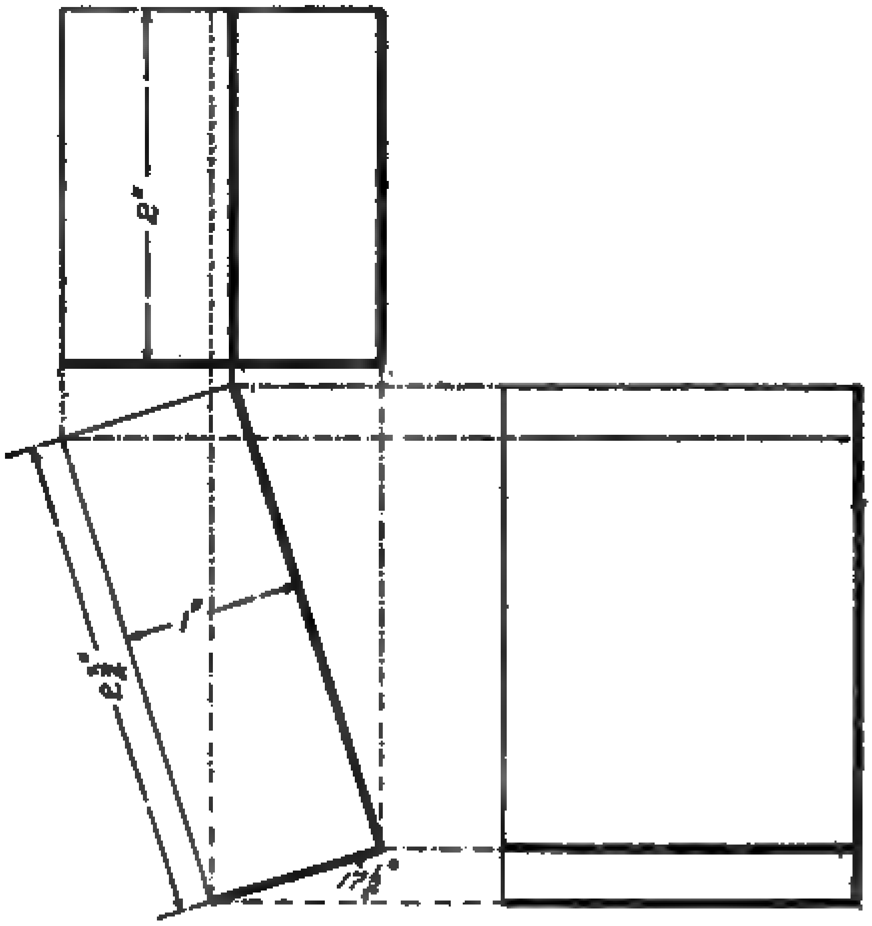


Fig 3.

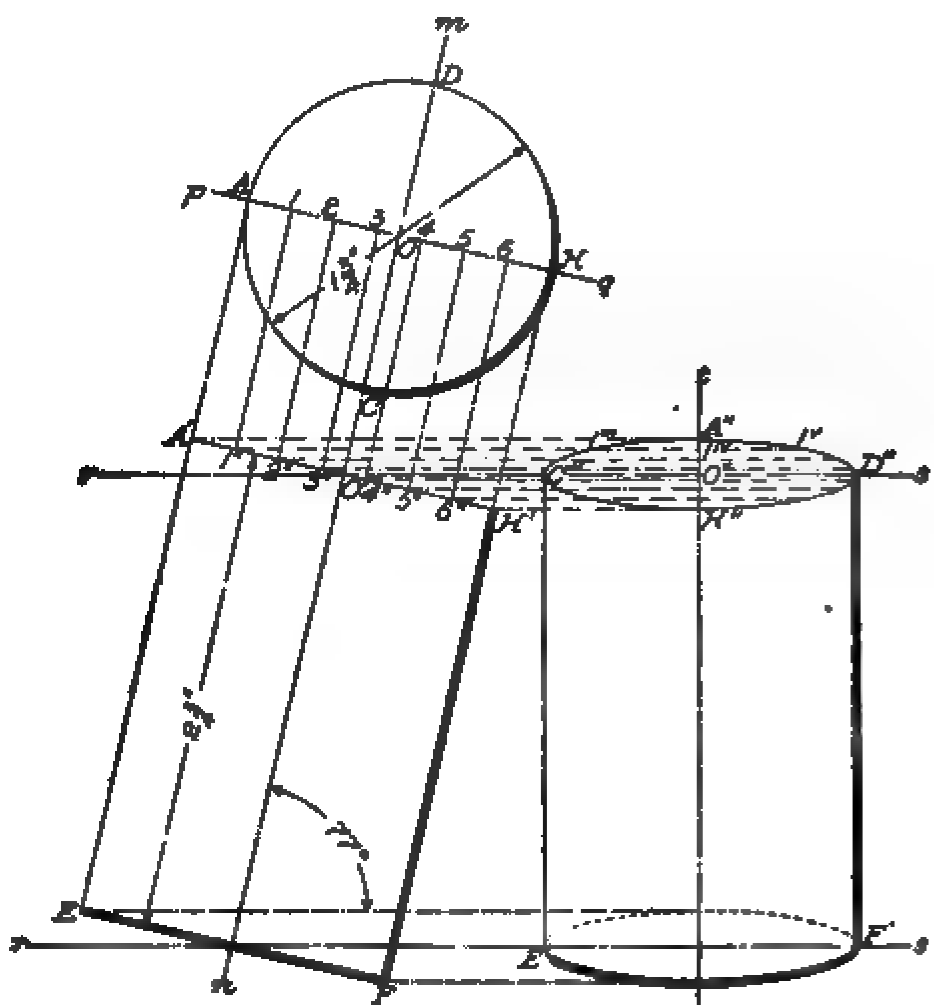


Fig. 6.

Fig. 2 is the same **prism** shown in Fig. 1, but in a different position. The two broad sides are parallel to the plane of the paper, and the prism is tipped in such a manner that the base makes an angle of 160° with the horizontal. The elevation must be drawn first. To do this, draw a horizontal line; then, by using the protractor, draw the line *E F*, making an angle of 160° with the horizontal, reckoning from right around to the left, opposite to the motion of the hands of a clock. Make *E F* equal in length to 2″, and on it construct the rectangle *E F B A*, 2¾″ × 2″; it will be the vertical projection or front elevation of the prism. The method of drawing the plan and side elevation is apparent without further explanation.

Fig. 3 is the same **prism** shown in Figs. 1 and 2, but with the narrow sides parallel to the plane of the paper, and tipped until the base makes an angle of 17½° with the horizontal. The sizes are the same as in the two preceding figures, and it should be drawn without further explanation, the front elevation being drawn first.

Fig. 4 shows a **hexagonal prism** having two of its parallel sides parallel to the plane of the paper, and its axis vertical; instead of a side elevation at right angles to the horizontal, a side elevation is desired as if the vertical prism were looked at in the direction of the arrow, or at an angle of 30° with the horizontal. Draw the plan first and then the front elevation from the dimensions given. To draw the other view, first draw the center line *m n*, and then, by use of the T square and 30° triangle, draw the lines *A B*, *C D*, *E F*, and *G H*, from the points *A*, *C*, *E*, and *G*, as shown. Also draw in a similar manner the other four dotted lines at the base of the prism; then draw the line *I B* at a right angle to the lines *A B*, *C D*, etc. At the point *I*, draw the line *I J* parallel to the center line *m n*, and, with *I* as a center, and the points *B*, *D*, *F*, *H*, *K*, *L*, etc. as radii, describe arcs, as shown, cutting the vertical line *I J* at the points *J*, *M*, *N*, *O*, *P*, *Q*, etc. Through the points *J*, *M*, *N*, *O*, *P*, *Q*, etc., draw horizontal lines as shown. On each side of the vertical center line *m n*, lay off a distance of ¾″, or one-half the

distance between the parallel sides of the prism, which is $1\frac{1}{2}''$, as shown in the plan, and draw the lines RS and TU. This view is then completed by drawing the lines VR, VT, WX, and YX, as shown. The lines at the base are drawn in a similar manner.

Fig. 5 represents a **hexagonal pyramid** whose axis is parallel to the plane of the paper, the base making an angle of 30° with the horizontal. It is desired to find the vertical projection of the side elevation. Having drawn the plan, $A\,B\,C\,D\,E\,F$, and the side elevation, $O'A'\,B'\,C'\,D'$, as shown from the dimensions marked on the drawing, choose the position of the vertical center line $t\,v$; project O' and O''' upon it in the points O'' and O^{IV}, and, through O^{IV} and O''', draw a fourth center line $r\,s$. On this, lay off $O^{\text{IV}}\,G'$ and $O^{\text{IV}}\,H'$ equal to $O\,G$ and $O\,H$, and construct the projection $A''\,B''\,C''\,D''\,E''\,F''$, as indicated by the broken and dotted lines. Join $O''\,E''$, $O''\,F''$, etc. by straight lines, and it will be the required projection. The figure thus drawn represents the pyramid as it would appear placed so that its base made an angle of 30° with the horizon, the line of vision being horizontal to the observer looking at it from the left side.

Fig. 6 shows a **cylinder** whose axis is parallel to the plane of the paper and makes an angle of 77° with the horizontal. The vertical side projection is required. Draw the plan and front projection as shown from the dimensions given. Draw the center line $t\,v$ vertical, and project the center O' upon it in O''; also, A' in A'', and H' in H''. To find the remaining points on the projected circle, divide the diameter $A\,H$ of the plan into a convenient number of equal parts, in this case 7, as $A\,1$, 1–2, 2–3, etc. Through the points thus laid off, draw the lines 1–$1''$, 2–$2''$, 3–$3''$, etc., parallel to the center line $m\,n$. Through the points A', $1''$, $2''$, $3''$, etc., draw the horizontal lines as shown by the dotted lines. From and on each side of the vertical center line $t\,v$, lay off distances on each side of the horizontal lines just drawn equal to the length of that part of the lines 1–$1''$, 2–$2''$, 3–$3''$, etc. included between the center line $p\,q$ and

the semicircle $A C H$; thus, on the horizontal line drawn through the point O', the distances $O'' C''$ and $O'' D''$ are each equal to $O C$ in the plan. The distances $1^{IV}\ 1\text{-}'''$ and $1^{IV}\text{-}1^{V}$ are each equal to the distance from 1 to the point of intersection of the semicircle on the line $1\text{-}1''$. The remaining distances are laid off in a similar manner. A curve traced through the points thus found will be the required projection of the upper base of the cylinder. The projection of the lower base is found in exactly the same way. Drawing $C'' E'$ and $D'' F'$ completes the required projection.

DRAWING PLATE, TITLE: CONIC SECTIONS.

47. This plate shows the different forms of the curves formed by the intersection of a cone or cylinder by a plane. If the plane of intersection is perpendicular to the axis of the cone or cylinder, the curve of the intersection will be a circle; but, if it is inclined to the axis, it will be an ellipse in the case of a cylinder, and an ellipse, hyperbola, or parabola in the case of a cone, according to the angle of inclination.

Fig. 1 is a **cone cut by a plane** which does not intersect the base of the cone. *When the cutting plane does not intersect the base*, no matter how much the cone may be extended, the curve of intersection is an **ellipse.**

Draw the plan and front elevation of a right cone whose altitude is $3\frac{1}{4}''$, and whose base is $3''$ in diameter. Cut this cone by a plane $a b$, making an angle of 52° with the base. See figure.

Divide the circle which represents the base of the cone in the plan into any number of parts, in this case 24, and, through the points of division A, E, H, etc., draw the radii $O A$, $O E$, $O H$, etc. to the center O. Draw also from these points straight lines $A A'$, $E E'$, $H H'$, $B B'$, etc., parallel to the axis of the cone $O' n$, and cutting the base $A' B'$ in the points E', H', etc. From these points, draw lines to the apex O' of the cone, and cutting the base $A' B'$ in points

E', H', etc. From these points, draw lines to the apex O' of the cone, as $E' O'$, $H' O'$, etc., cutting the plane $a b$ in the points D', F', etc. From these points D', F', etc., draw straight lines $F' F F''$, $D' D D''$, etc., parallel to the axis $O' n$ of the cone, and intersecting the radii $O A$, $O E$, $O H$, $O B$, etc. in the points C, D, F, K, F'', D'', etc., and through these points of intersection, draw the ellipse by aid of an irregular curve.

Fig. 2 is a cone of the same size as in the preceding problem; but the cutting plane $a b$ is, in this case, parallel to one of the elements* of the cone, and intersects the base. The curve formed by the intersection of a cone by a plane parallel to one of its elements is called a **parabola.** The plan and front elevations of the cone and curve of intersection are found in a manner similar to the method used in the last problem. To find the side elevation, proceed as follows: Draw the side elevation $O'' A'' B''$ of the cone with the center line $t v$ as its axis. Draw the projection lines $F' F''' F^{IV}$, $D' D''' D^{IV}$, etc., and make $K' F'''$ and $K' F^{IV}$ equal to $K F$ and $K F''$; make $I' D'''$ and $I' D^{IV}$ equal to $I D$ and $I D''$, etc., and trace a curve through the points thus found. The result will be the side elevation of the cone when cut by a plane parallel to one of its elements and having the upper part removed. The side elevation of Fig. 1 may be drawn in a similar manner.

Fig. 3 is a cone having the same dimensions as the two preceding problems, but cut by a plane $a b$ parallel to the axis of the cone and perpendicular to the vertical plane of projection. When the cutting plane intersects the base of a cone and is not parallel to any element (that is, if the acute angle included between the cutting plane and the base is greater than the angle $O' A' B'$ included between any one element and the base), the curve of intersection is called a **hyperbola.**

The plan and front elevation are constructed as before, the

* Any straight line drawn on the surface of a cone and passing through the apex (as $O' H'$, Fig. 1, or $O' A'$, Fig. 2, etc.) is called an element.

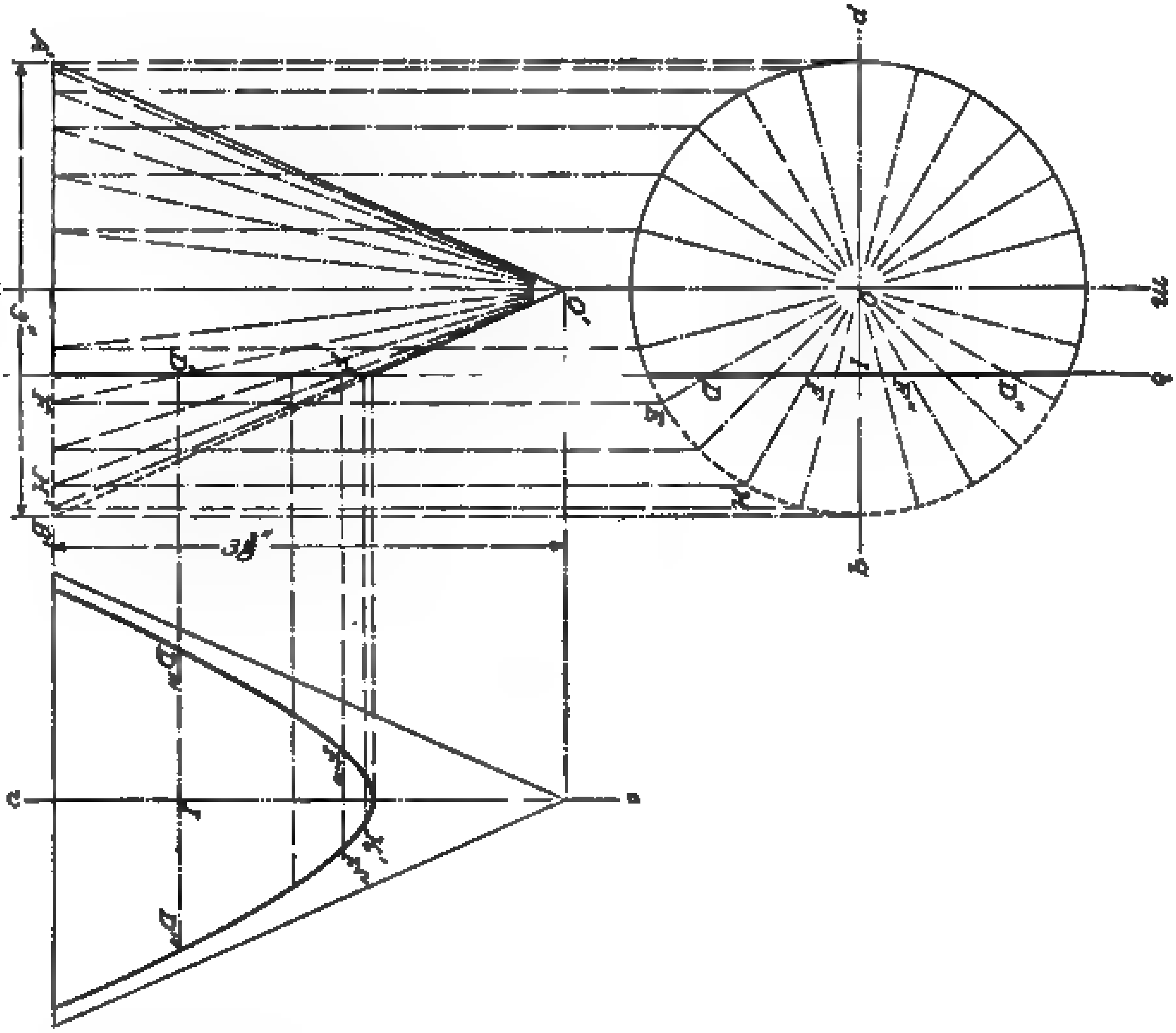


Fig. 3.

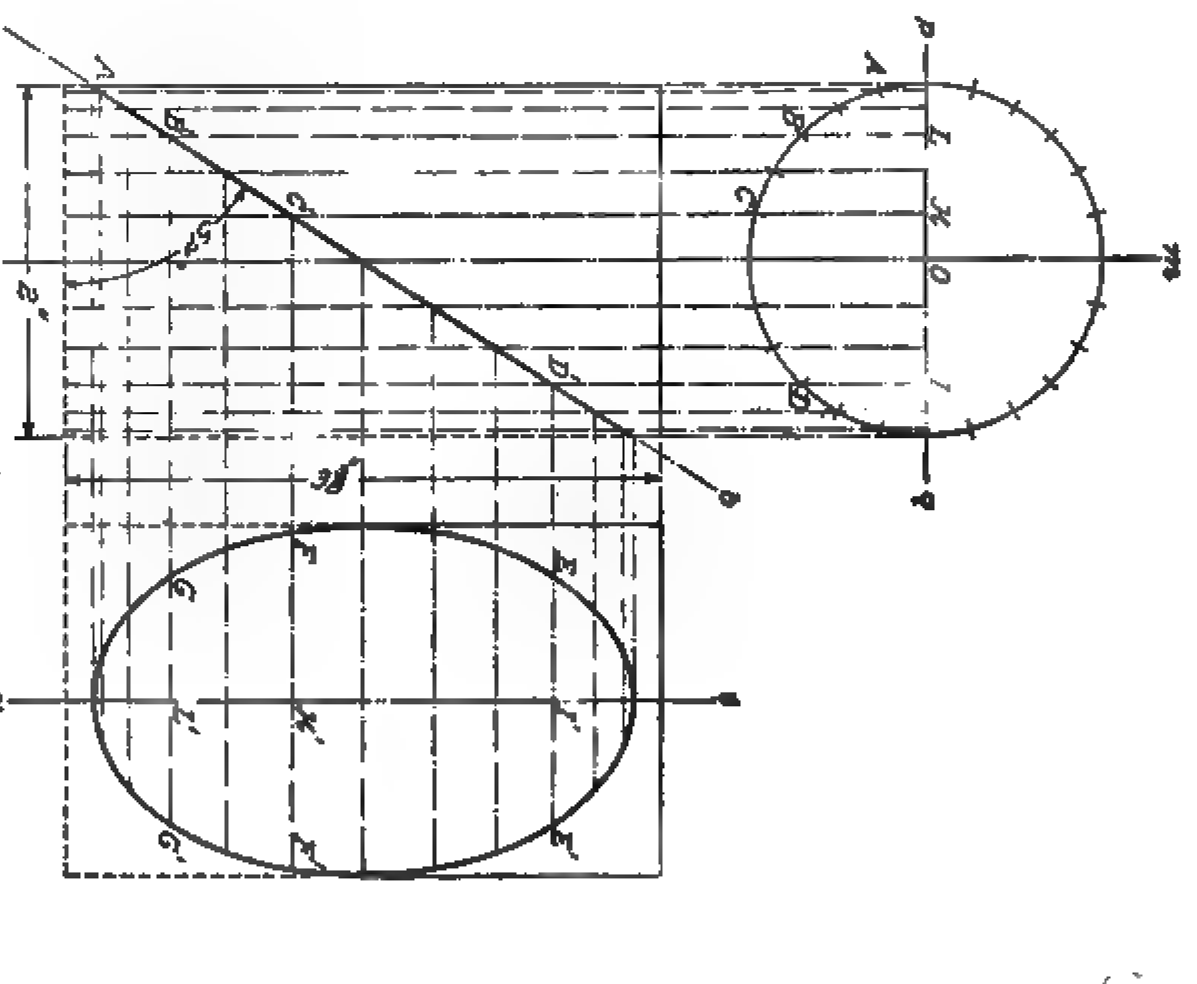
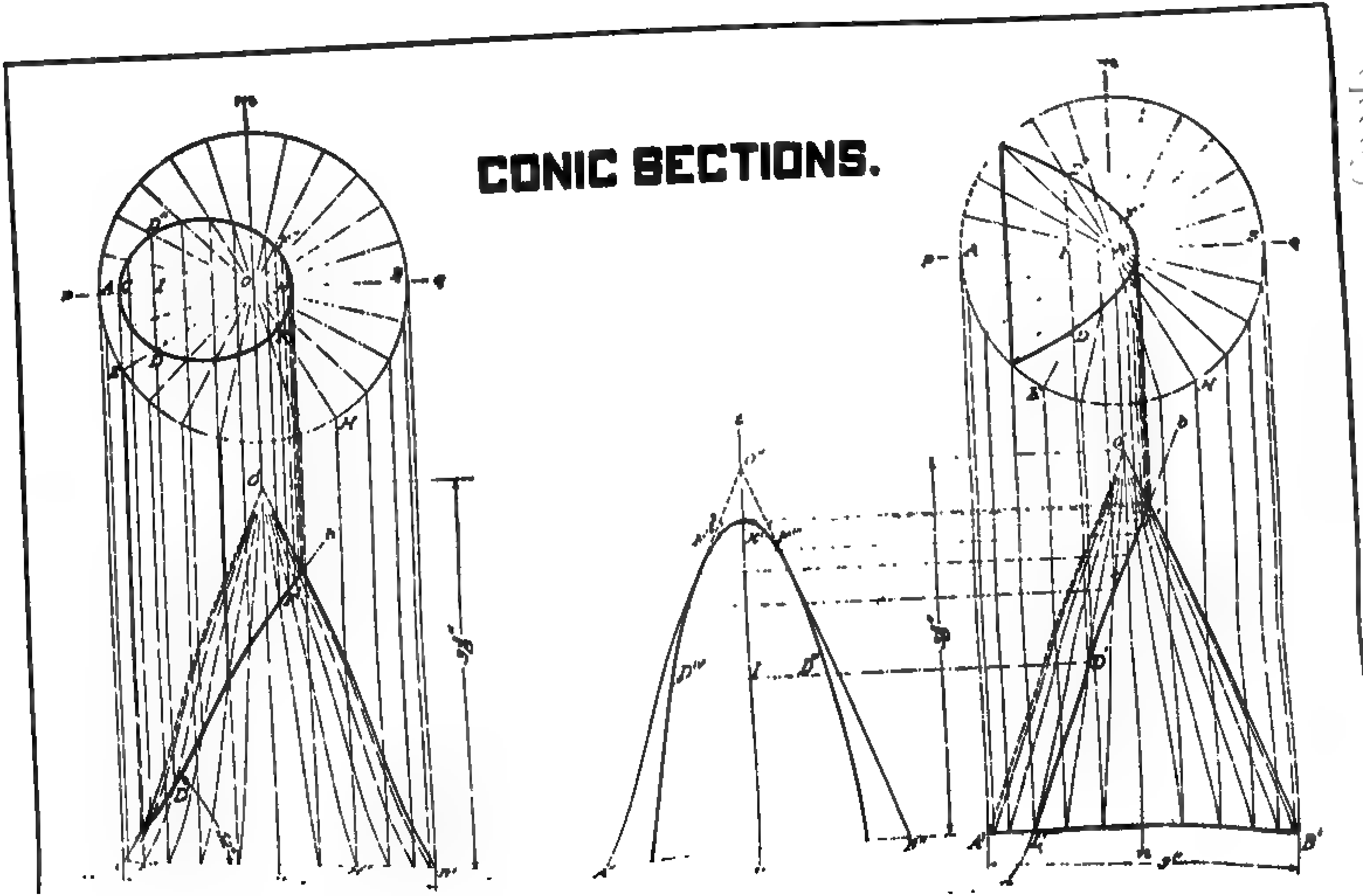
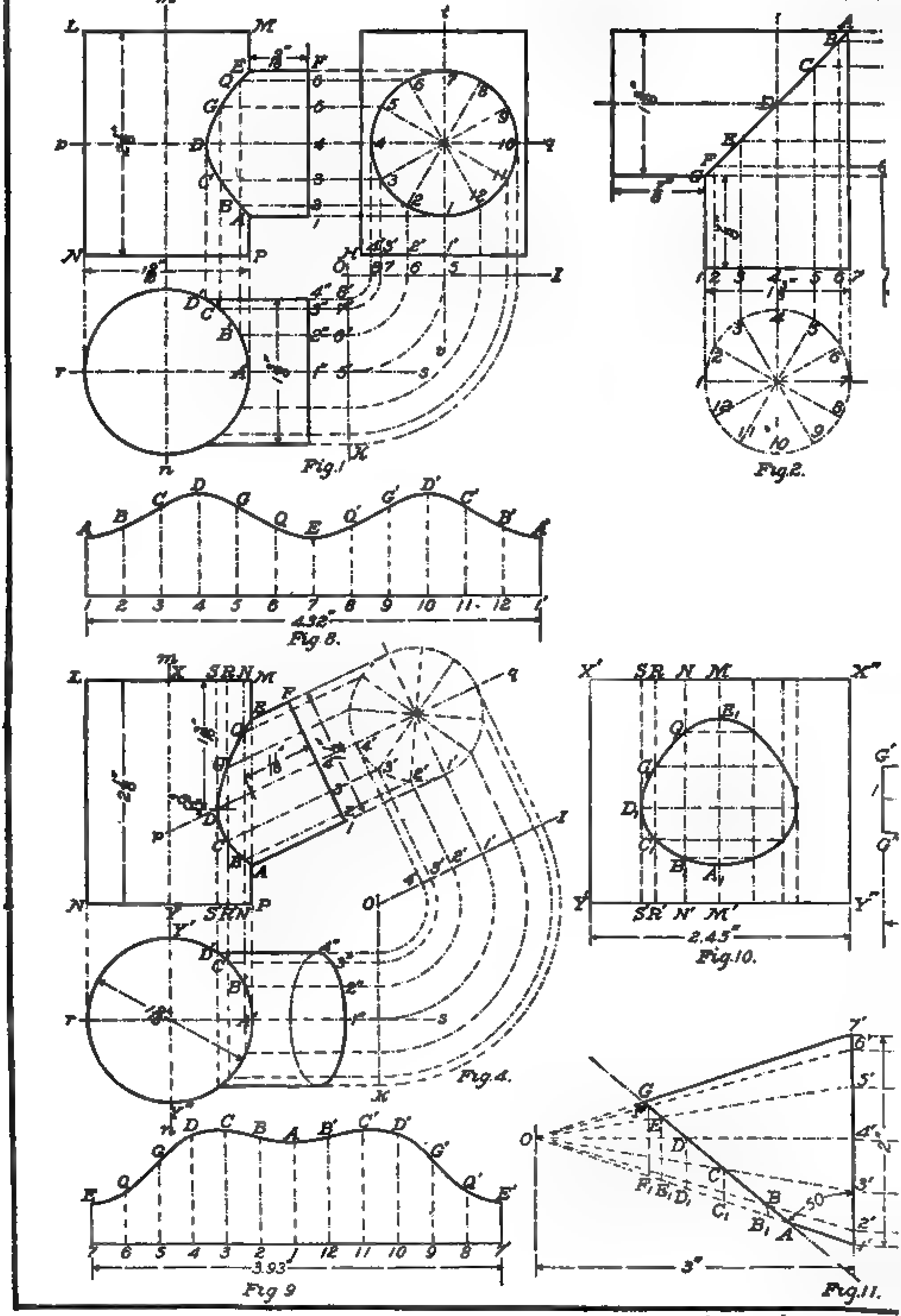


Fig. 4.

CONIC SECTIONS.



INTERSECTIONS AI



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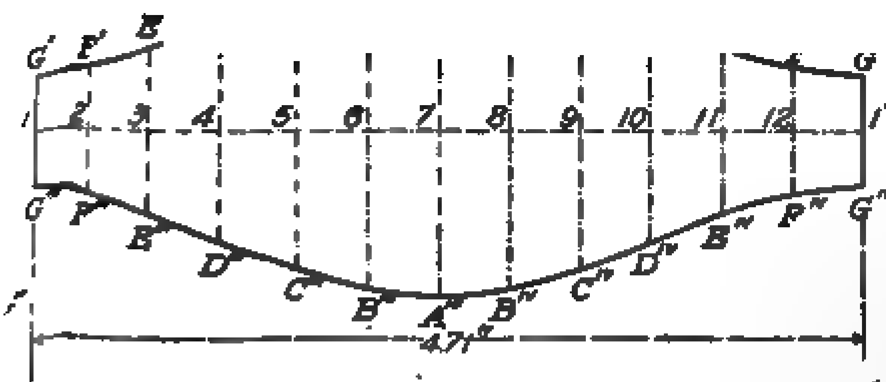
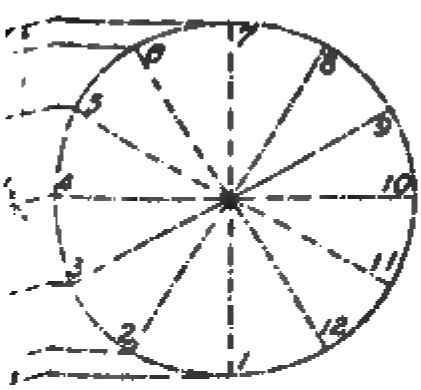


Fig. 7.

Fig. 5.



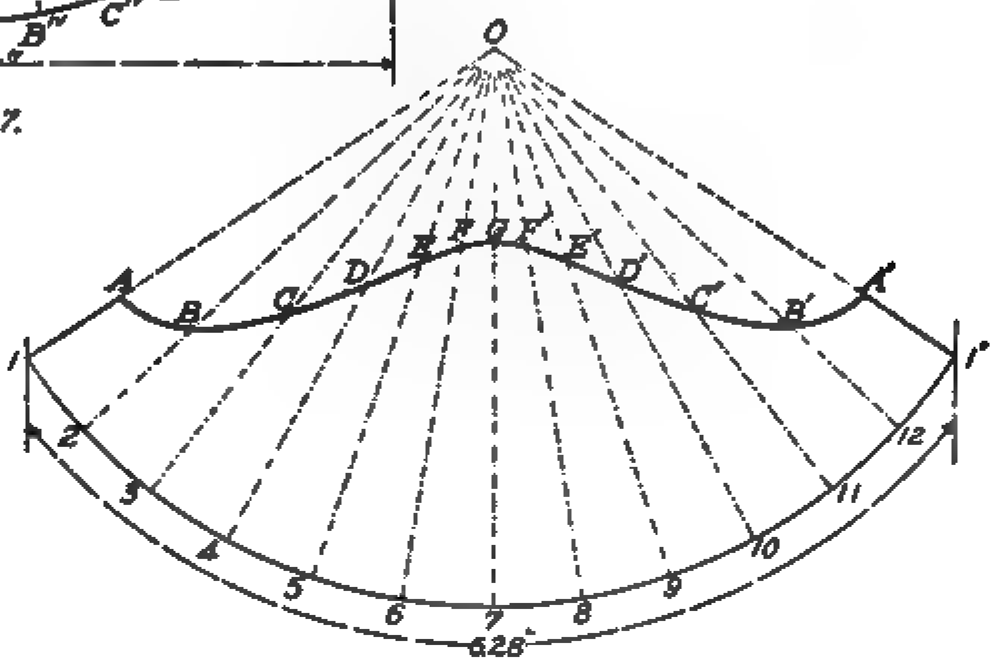


Fig. 12.

$O7' = O7$, etc.; this may be most conveniently done by taking O as a center, and describing arcs of circles with radii equal to $O8$, $O7$, $O6$, etc., cutting OK in $8'$, $7'$, $6'$, etc. Through $8'$, $7'$, $6'$, etc., draw the lines $8'D'$, $7'C'$, $6'B'$, etc., parallel to the center line rs. Through the points D', C', B', and A', draw the lines $D'D$, $C'G$, and $B'Q$, parallel to the center line mn, and intersecting the lines $4D$, $5G$, $6Q$, $3C$, and $2B$ in the points D, G, Q, etc. The curve traced through these points will be the front elevation of the curve of intersection of the two cylindrical surfaces.

Fig. 2 shows the intersection of **two equal cylindrical surfaces** at right angles to each other, as in the case of a pipe elbow. When two cylinders having *equal diameters intersect, and their axes also intersect*, the front elevation of the curve of intersection is always a straight line, no matter what angle the two axes make with each other.

Fig. 3 shows a symmetrical **three-jointed elbow** formed by the intersection of three cylindrical surfaces. The diameter of each of the three surfaces is $1\frac{1}{2}''$. The center lines of the surfaces $RAGS$ and $MNPH$ are to be at right angles to each other; then, in order that the arrangement shall be symmetrical, the center line of the third surface $AMHG$ must make an angle of 45° with the center lines of the other two.

To construct the elevation as shown in the figure, draw the two center lines mn and pq at right angles to each other; they intersect at 6. Lay off $6I = 1\frac{1}{4}''$ and draw an indefinite line RS through I perpendicular to mn. Make IR equal to $IS = 1\frac{1}{2} \times \frac{1}{2} = \frac{3}{4}''$, and draw RA and SG parallel to mn. Draw OK parallel to mn and $1\frac{1}{2}''$ below it. Through the point O, where RS and OK intersect, draw OT passing through 6, and bisect the angle ROT by the line OA, which intersects RA and SG in A and G. Lay off $6J = 2\frac{1}{4}''$ and draw PJN perpendicular to pq. Make $JP = JN = 1\frac{1}{2} \times \frac{1}{2} = \frac{3}{4}''$, and draw PH and NM parallel to pq. Draw OM so as to bisect the angle TOK; OM intersects PH and NM in H and M. Finally, draw AM and GH.

Fig. 4 shows the intersection of two **unequal cylindrical surfaces** whose axes intersect at an angle of 65° instead of 90°, as in Fig. 1. The method of finding the curve of intersection is in all respects similar to that used in Fig. 1, and, as the corresponding points have been given the same letters or figures, the directions given for Fig. 1 can be applied to Fig. 4 also.

Fig. 5 shows a **cylindrical piece of iron** $2\frac{11}{16}''$ in diameter that has been gradually turned down to $1\frac{5}{16}''$ diameter, and then having the larger part flattened on two sides. The large and small parts of the piece are connected by a graceful curve. The problem is to find the curve of intersection $A\ 1\ 2\ 3\ B$ formed by the flattening. Draw the plan and front elevation from the dimensions given; also draw the curve $C\ 6'\ 5'\ 4'$, and its equal on the opposite side, so that they look to the eye about as seen in the drawing. In order that all the work sent to us may be alike, the radius of this curve and the position of the center have been given on the drawing. To locate the center, draw an indefinite horizontal straight line, $1'' + 1\frac{1}{16}'' = 2\frac{1}{16}''$ above the base of the piece; and with C and D as centers, and a radius of $1\frac{1}{8}''$, describe short arcs cutting the line just drawn. The points of intersection will be the required centers. With O as a center, and radii of convenient lengths, as $O\,4$, $O\,5$, $O\,6$, etc., describe arcs cutting $A'B'$ in $3'$, $2'$, $1'$, etc. Through the points 4, 5, 6, etc., draw the lines 4–$4'$, 5–$5'$, 6–$6'$, etc., parallel to the center line $m\,n$, and intersecting the curve $C\,4'$ in $4'$, $5'$, $6'$, C, etc. Through the points A', $1'$, $2'$, etc., draw lines $A'A$, $1'$–1, $2'$–2, etc., parallel to $m\,n$ intersecting horizontal lines drawn through C, $6'$, $5'$, $4'$, etc., in A, 1, 2, 3, etc. The points A, 1, 2, 3, etc. are points on the required curve, and through them the curve may be drawn.

Fig. 6 is the **cylindrical surface** of one section of the elbow $1\,7\,A\,G$ of Fig. 2 rolled out into a flat plate; hence, if a flat plate be cut into the same shape and size as Fig. 6 and bent into a cylinder so that the ends $1\,G'$ and $1'\,G''$ touch each other, the vertical projection or front elevation would be the same as shown by $1\,7\,A\,G$ in Fig. 2. If a second

plate were cut out in the same manner, and bent into a circle, the two pieces on being brought together, as shown in Fig. 2, would touch at every point. The problem is to find the shape of the curve $G'A'G''$. The length of the line *1–1'* is evidently equal to the length of the circumference of a circle whose diameter is $1\frac{3}{8}''$, or $4.32''$, very nearly. Produce the line *1–7*, Fig. 2, and make *1–1'* equal in length to $4.32''$. Divide the circle *1 2 3 . . . . 12* into a convenient number of equal parts, in this case 12, and erect the perpendiculars *1 G*, *2 F*, *3 E*, etc., cutting the line of intersection *G A* of the cylindrical surfaces in *G*, *F*, *E*, etc. Divide the line *1–1'* into the same number of equal parts that the circle was divided into, thus making the length *1–2* equal length of arc *1–2*; *2–3*, length of arc *2–3*, etc. Through *1*, *2*, *3*, etc., draw the perpendiculars $1\,G'$, $2\,F'$, $3\,E'$, etc., and project the points *G*, *F*, *E*, etc., upon these perpendiculars, as shown, thus locating the points G', F', E', D', C', B', A' of the left-hand half of the required curve. The points on the right-hand half are found in the same manner, as shown, and the required curve can be drawn through these points.

50. A drawing like Fig. 6 is called the **development** of the cylindrical surface *1 7 A G*.

Fig. 7 is the **development of the cylindrical surface** *A G H M* of Fig. 3. Make $1\text{–}1' = 1\frac{1}{2} \times 3.1416 = 4.71''$, nearly, and divide it into 12 equal parts to correspond with the 12 equal parts into which the dotted circle is divided. Project the points *6*, *5*, etc. of the dotted circle upon *O A* as shown, thus locating the points *B*, *C*, etc. Through *B*, *C*, etc., draw *B 6*, *C 5*, etc., perpendicular to *O T*. Make $1\,G' = 1\,G''' = 1\,G, 2\,F' = 2\,F''' = 2\,F, 3\,E' = 3\,E''' = 3\,E$, etc. Through G', F', E', etc., trace the curve $G'\,F'\,E' \ldots . G''$, and, through G''', F''', E''', etc., trace the curve $G'''\,F'''\,E''' \ldots . G^{\text{IV}}$. Drawing $G'\,G'''$ and $G''\,G^{\text{IV}}$ completes the figure.

Fig. 8 is the development of the cylindrical surface *1 F E A*, Fig. 1. The method used here is in all respects similar to the two preceding problems. In this case, the distances

1 A, *7 E*, and *1′ A′* are all equal to *1 A* or *E F*, in Fig. 1; and *2 B*, *6 Q*, *8 Q′*, and *12 B′* are all equal to *2 B* or *6 Q*, in Fig. 1. The development of *L M P N* is not given, for want of room, but the method will be explained in Fig. 10.

Fig. 9 is the development of the cylindrical surface *1 F E A*, Fig. 4. The student should have no difficulty in drawing this, after having studied the preceding problems.

Fig. 10 is the development of the cylindrical surface *L M P N*, Fig. 4. Owing to the want of room, only that half of the development is shown which contains the part to be cut out. The length of a circle $1\frac{9}{16}''$ in diameter is 4.9″, nearly; half of this is 2.45″. Hence, the line $Y' Y''$, Fig. 10, which equals the length of the semicircle $Y' A' Y''$, Fig. 4, is 2.45″ long. The distance $X' Y' = X'' Y''$ equals the length of the cylinder, *L N* or *M P*. Lay off $X' S$ equal to the length of the arc $Y' D'$; *S R* equal to the arc $D' C'$; *R N* equal to the arc $C' B'$; *N M* equal to the arc $B' A'$, etc. Find the lengths of these arcs by means of the method given in connection with Fig 49. Draw through these points the perpendiculars $S S'$, $R R'$, etc. With the spacing dividers, set off $S D_1$ equal to *S D* in Fig. 4; $R G_1$ equal to *R G*; $N Q_1$ equal to *N Q*; and $M E_1$ equal to *M E*. Also, $R' C_1$ equal to $R' C$; $N' B_1$ equal to $N' B$; and $M' A_1$ equal to *P A*. In exactly the same manner, find the points on the right-hand half of the curve. If a plate were cut of the same size and shape as shown in Fig. 10, and rolled into a semicylindrical surface, the diameter of which is $1\frac{9}{16}''$, it would exactly fit the plate cut like Fig. 9 rolled into a cylindrical surface, the diameter of which is $1\frac{1}{4}''$, the two being placed together as shown in Fig. 4.

Fig. 11 shows a **conical surface cut by a plane,** and Fig. 12 shows its **development.** Draw the elevation and horizontal projection of the base as shown in Fig. 11. Divide the projected circle (base of cone) into a convenient number of equal parts, in this case 12, and project the points *1*, *2*, *3*, etc. on the base *1′–7′*, thus locating the points *1′*, *2′*, *3′*, etc. Join these points with the apex *O* of the cone, by the lines *O 1′*, *O 2′*, *O 3′*, etc., cutting the plane in *A*, *B*, *C*, etc. Now,

choose a convenient point O, Fig. 12, and with this as a center, and a radius equal to $O\,1'$, or $O\,7'$, Fig. 11, the slant height of the cone, describe an arc 1–$1'$ of a circle. Make the *length of this arc* equal to the length of the circumference of a circle having the same diameter as the base of the cone. This may be conveniently done as follows: length of arc $= 2 \times 3.1416 = 6.28''$, nearly. Draw a straight line 6.28″ long and divide it into, say, 4 equal parts. Describe an arc having a radius equal to $O\,1'$, the slant height of the cone, and find the length of a part of this arc equal to $6.28 \div 4 = 1.57''$ by means of the method described in connection with Fig. 48. With the dividers set for the chord of the arc just found, space off the chord four times on the longer arc $1\,2\,3 \ldots . 1'$, Fig. 12. Divide the arc into the same number of equal parts that the circle $1\,2\,3 \ldots . 12$ has been divided into, that is, 12 parts. Join the points of division 1, 2, 3, etc., with the center O by the lines $O\,1$, $O\,2$, $O\,3$, etc., as shown. Project the points B, C, D, etc., Fig. 11, upon $O\,1'$, in B_1, C_1, D_1, etc., as shown, and lay off $O\,A$ equal to $O\,A'$ equal to $O\,A$, Fig. 11; $O\,B$ equal to $O\,B'$ equal to $O\,B_1$; $O\,C$ equal to $O\,C'$ equal to $O\,C_1$, etc., and through these points draw the curve. A plate cut of the same size and shape as shown by $A\,G\,A'\,1'\,7\,1$ can be bent into the conical surface shown by the elevation $A\,G\,7'\,1'$.

Particular attention must be given to the method explained above for laying out the curve of the development in Fig. 12. It would be entirely wrong to take the measurements from the lines $O\,F$, $O\,E$, $O\,D$, $O\,C$, etc., Fig. 11. The reason for this is that these lines, being on the surface of the cone, are inclined toward the observer, and so do not appear in their true length. The line $O\,D$, for example, if measured on the surface of the cone itself, would evidently be of the same length as the line $O\,D_1$; but, in the figure, it is much shorter. The line $O\,D_1$, however, appears in its true length in the figure, because it is not inclined to the observer in the position shown. The actual distance of point D from the apex O, therefore, is $O\,D_1$, which is the distance to be laid off for point D in the development. The same holds true for the other points.

SHADE LINES.

51. The use of the heavy shade line will now be explained. In Fig. 71, by means of the shade lines, the draftsman knows, without looking at any other view of the object, that the rectangles *1* and *4* represent square holes, and *2* and *3*, square bosses. When he looks at the other view, it is to find the depth of the holes and the height of the bosses. This explains the use of the shade lines, viz.: to show, from that view of the drawing which is being examined, whether the part looked at is above or below the plane of the surface; that is, for example, whether the rectangles *1*, *2*, *3*, and *4* are the tops of bosses or bottoms of holes, and, consequently, whether they extend above or below the surface of *A B D C*. In order that the shading may be uniform on all drawings, the light is assumed to come in one invariable direction, in such a manner as to be parallel to the plane of the paper, to make an angle of 45° with all horizontal and vertical lines of the drawing, and to come from the upper left-hand corner of the drawing. Each view of the object represented is shaded independently of any of the others; and, when shading, the object is always supposed to stand in such a position that the drawing will represent a top view. Any surface that can be touched by drawing a series of parallel straight lines, making an angle of 45° with the horizontal and vertical lines of the drawing, is called a **light surface**; a surface that cannot be touched by lines having this angle is called a **dark surface.** All of the edges caused by the intersection of a light and dark surface, or two dark surfaces, are usually shaded; that is, the edges

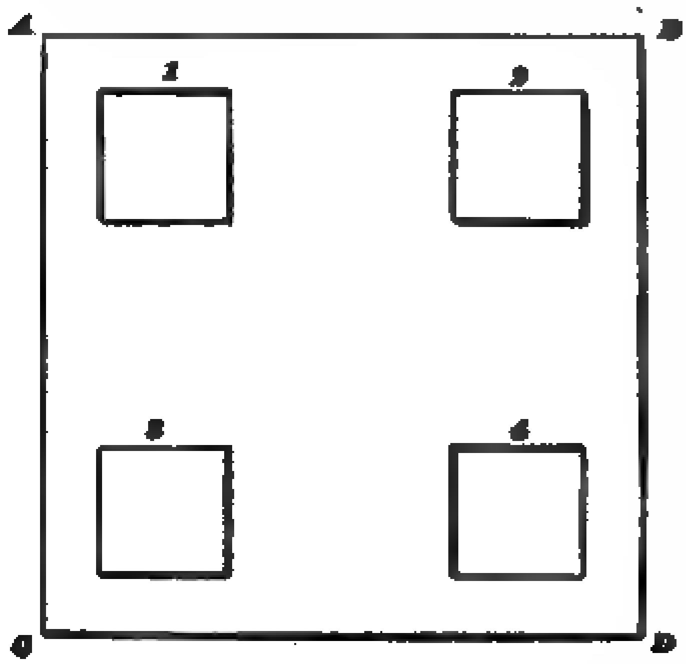


FIG. 71.

thus formed are drawn in heavy lines. Exceptions to this rule are sometimes made by experienced draftsmen, when a rigid adherence to it will produce a bad effect or will render the drawing ambiguous.

Fig. 72 shows a plan of a series of triangular wedges radiating from the common center *O*. The top is, of course, a light surface, and, in order to determine whether the perpendicular surfaces are light or not, the 45° triangle may be used. Take the wedge *R O A*. A line drawn at an angle of 45°, the direction of the arrows, would strike the side of which *O A* is the edge; hence, this side is a light surface, and the top being also a light surface, the line *O A* must be light. *O R*, on the contrary, is a heavy line, since the light cannot strike the side of which *O R* is the edge without passing through the wedge. Hence, this is a dark surface, and its intersection *O R* with the light surface *O A R* requires a shaded line. For the same reason, *A R* is also shaded. The same reasoning as the above applies to the lines *O B*, *O D*, *O G*, *O I*, *O K*, and *O M*; also, to *Q N*, *M L*, and *K J*. *C B* is not shaded, because the light strikes the surface of which *C B* is the edge, as shown by the arrow, making *C B* the intersection of two light surfaces. *O N* makes an angle of exactly 45° with the horizontal, and is treated as if it were the edge of a light surface; this is done in every case in which the line considered makes an angle of 45° with the horizontal.

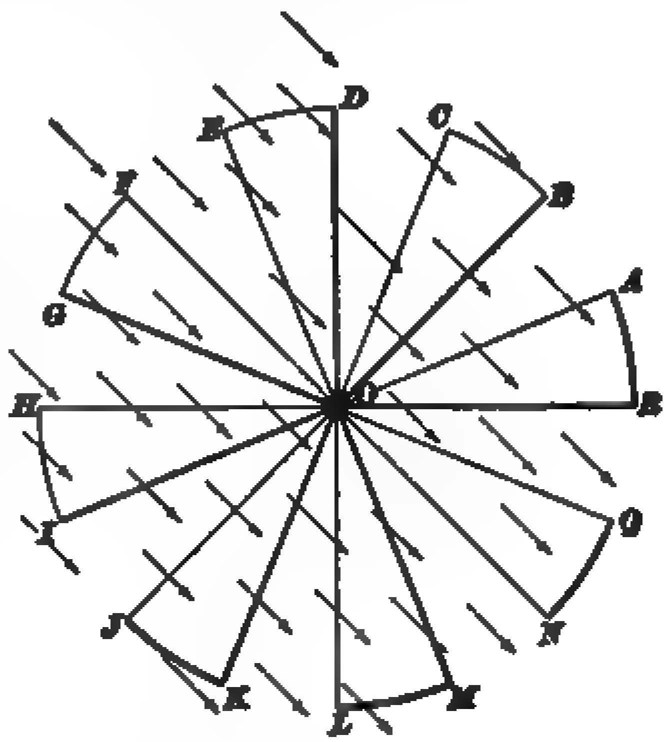


FIG. 72.

In shading holes, or any parts of the drawing denoting depressions below the surface under consideration, a slightly

different assumption is made. Fig. 73 shows the plan of a square block with a hexagonal hole in the center. If the light passed over the surface $ABCD$, parallel to the plane of the paper as previously assumed, all of the inside surfaces would be dark, and the entire outline of the hexagon $EFGHIK$ would be shaded. In order to prevent this and make the work similar to that which has preceded, the rays of light are assumed to make an angle of 45° with the plane of the paper when shading holes and depressions. Hence, the light will strike the surfaces whose edges are GH, HI, and IK, as shown by the arrows, leaving the surfaces whose edges are KE, EF, and FG dark as before. Therefore, these latter edges will be shaded, and the edges GH, HI, and IK will be light. See also Fig. 71.

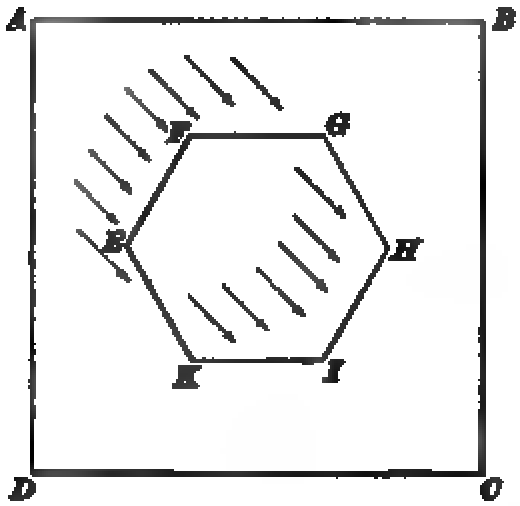


FIG. 73.

The conventional method of shading circles which represent the projections of cylinders, or circular holes, is as follows: AB, Fig. 74, is the projection or end view of a cylinder having for a base the circular area AB. Draw the arrows EA and FB, making angles of 45° with the horizontal diameter, and tangent to the circle at A and B. That half of the circle in front of these two points of tangency is to be shaded, and, in order to make the drawing look well, the center point for the compasses is shifted along the line CH parallel to EA and FB

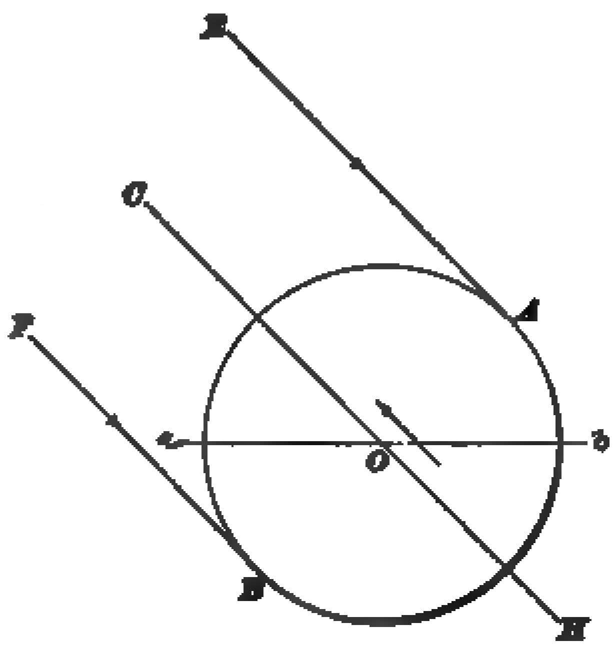


FIG. 74.

in the direction of the arrow an amount equal to the thickness of the desired line. With the same radius that was used to describe the original circle, describe part of another circle, being careful not to run over the first circle, and stopping when the two lines coincide. The directions for shading a hole are precisely the same as for the projection of a cylinder base, except that the half *B C A* of the circle in Fig. 75 is to be shaded, the center being shifted as before, but in the opposite direction, as shown by the arrow.

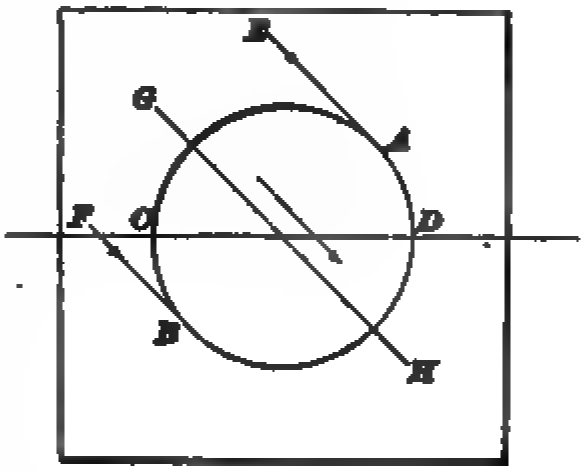


FIG. 75.

Vertical projections of cylinders are shaded as shown in the front elevation of Fig. 5, Drawing Plate, title: Projections I.

After studying the foregoing concerning shade lines, the student should be able to see the reason for the using or omitting of any shade lines on the drawings in the following plates. In the case of an object like the hexagonal prism in Fig. 6, Drawing Plate, title: Projections I, no part of the upper base or line *S e* is shaded, although, strictly speaking, the part *c e* of the line should be shaded; but, as this would make part of the straight line *S e* heavy and the greater part light, the whole line is drawn light. This is one of the exceptions previously mentioned.

FREEHAND DRAWING.

INTRODUCTION.

1. History of Ornament.—The history of ornament in architecture and the technical arts antedates all written history. One of the strongest characteristics of even the most savage tribes is their attempt at ornamental design, expressed in rude carving, or in the painting of their bodies, weapons, or utensils. To this instinct may be ascribed the habit of tattooing practiced by many uncivilized nations, whereby they essayed to increase the expression of terror of countenance, and create what appeared to them an additional beauty. Uncivilized man has always been a *warrior*, and as such he ranked with his fellow man according to the bravery he exhibited before his friends, and the fear with which he inspired his enemies. For this reason nothing appeared beautiful to the savage, unless it possessed some element of the terrible or the supernatural. As man becomes civilized his tendency in ornamental design leans toward the reproduction of natural forms, and his self-glorification gives way to the desire to glorify the works of his Creator. Therefore, we always see some attempt to combine in the design some form from the animal or vegetable world, suggestive of the beneficence of Providence.

Ornamentation is thus seen to precede architecture historically, but it was the *art of building* that afforded the grandest field for its development and application. The noblest achievements in the technical arts have been produced

in the service of architecture; and in all art industries, even wherein ornamentation seems to follow an independent existence of its own, its products are in harmony with the contemporary taste and tendency of architecture. The historical style and development, and the technical execution of ornament, whether carved, painted, or woven, are thus seen to be inextricably interwoven with the history of architecture and the sister arts.

2. A Drawing.—A drawing is the expression of an idea by means of a picture; therefore, to draw an object is to represent it with all its characteristic features. Some ideas can be expressed clearly in writing, but others require a drawing in order to convey them to the mind. Drawing is not designing but is the means by which we express our ideas in design to one another. It would thus appear that, to teach the *drawing of ornament* in a comprehensive way, we should at the same time teach all about its design and application; but experience has proved that such a course complicates the work of elementary instruction, and is only adapted to those that have already learned to draw well, and that know something about design in general. The subject must be divided, and for those that just enter upon its study it is best to first learn *how to draw*, and then devote their energies entirely to the study of *how to design*.

This is the scope and aim of this Paper. In a series of carefully graded exercises, the student is led from the simple straight line to the more difficult problems, and the lessons are confined at first to *outline drawing*, the object being to develop, in the shortest possible time, such ready facility of the hand and judgment of the eye as will enable him to correctly draw any outline whatever.

Notwithstanding this program of making this course essentially one of *drawing lessons*, the text is enriched with explanations of the problems presented, to stimulate the student's interest in his work. Information thus obtained, gradually grows together in the student's mind, and enables him to more readily comprehend the subject he has in hand.

3. Ornament is either the embellishment of a structural feature, accentuating its form and purpose, in which case it is usually carved or molded *in relief*, or the ornament consists of a flat-surface decoration, such as a carpet pattern, wall paper, or a painted design. Ornament consists of a combination of straight and curved lines, independent, or joined with vegetable or animal forms, or exclusively of the latter—with or without color decoration. Some ornament is purely geometrical in character, and can be drawn entirely with instruments; other is partly freehand and partly geometrical work; and the remainder is entirely freehand work. Ornamental drawing includes the rendering of *form* itself, being the representation of such graceful lines as exist in the animal and vegetable world, and also those of man's own invention, as seen in the architectural moldings, in the sweeps and curves of furniture, in the scrolls and twists of wrought-iron work; and in the outlines of pottery, glassware, cutlery, vehicles, ships, machinery, etc. For instance, in an ornamental vase or a wrought-iron grille, the general form and the graceful lines and proportion of its parts are as much subject for ornamental drawing as is any individual ornament with which a part of either of these objects may be decorated.

4. How to Draw.—The making of a drawing can be said to consist of two parts, namely, the making of the individual lines and the composition. Straight and curved lines must be drawn *in strokes*, and not in dots nor in a succession of short scratches. The strokes must not be jerky nor detached, but *continuous*, each one being a continuation of the preceding one, and as long as one unconstrained movement of the finger joints will make them, which is about $\frac{3}{4}$ inch. No other method maintains so well the *direction* of the lines to be drawn, nor develops so readily the pliability of the hand and the judgment of the eye by fastening the attention of both on the making of a continuous line, instead of on the making of the *pieces* of a line.

In ordinary drawing the elbow may be rested on any part

of the drawing board that the case may require; but the ball of the hand should be as free as possible, in which position the hand will rest and travel along lightly on the first joint of the little finger.

The pencil recommended for practice is one corresponding to grade "S M" of the *Dixon* brand, but the final work on the drawing plates should be executed with a harder pencil. For aiding in the work, a soft waffle, or multiplex, rubber may be used to advantage, to clean up the drawing after the sketch is completed and just previous to the process of inking in. The final pencil lines must be firm and clean, but not heavy; and, if any corrections are necessary, an ordinary white Faber's rubber should be used. The student should keep a uniform round pencil point, of medium length, and avoid frequent sharpening, but maintain a good point by turning the pencil as he works. Avoid cheap pencils; they are a delusion as to economy, and their common lead smears up the drawing. Three golden rules to be observed by the student are: *Never wet the pencil; never use a very hard pencil; never use a short pencil.* The pencil should not be less than 5 inches long, in order that it may rest against the knuckle of the forefinger.

The *eye* must guide the hand in drawing, but should not be riveted too closely upon the pencil or drawing pen; a glance forwards and backwards over the work, to compare the *form* of the design and the direction of the lines, will enable the student to keep his work close to the original, which is all that is at present desired.

The draftsman, sitting at work, should avoid bending over the drawing in a cramped position, as it is likely to injure his eyesight, and will in no way benefit his work. An easy, natural attitude is the best. All subjects should be outlined in their normal aspect, not upside down nor sideways, the paper being straight in front of the draftsman; but, in the final rendering, especially when a drawing is to be inked in, there is no objection to turning the sheet or the body around, to make the work more convenient and thus produce perfect lines.

5. Composition.—This element of a *drawing* consists of the general grouping of the lines and masses of the design, according to the size or scale to which the drawing is made.

Before beginning to draw a figure, its *general effect* and characteristic shape *as a whole* should be carefully observed. The individual forms, the curves, and scrolls, and the cut of the foliage should then be studied; and its symmetry and the proportion of its parts, and the direction of its movement, should be borne in mind during the entire process of sketching it in. As to the *size* of the drawing in relation to the copy, model, or natural object, it is sufficient to say that some definite scale of enlargement or reduction should be followed, so that everything shall be maintained in *equal relative proportion*. In beginning to draw an object, first lay out the extreme outline, as in Fig. 1; then locate all the principal points of extent and position by measuring from the base and center lines. The extreme outline should be composed of a few straight lines so arranged as to enclose the object in an irregular geometrical figure. The curves and other details of the object may then be rounded in at the angles of the geometrical figure, as shown. For this measuring and locating, *extreme exactitude is not required;* there should, in fact, be as little mechanical measuring as the student can get along with, all minor details being gauged by the eye. Use the *eye* as much as possible, in order that it may become trained to judge correctly of absolute and relative sizes, of form and proportion. The value of this accomplishment to the draftsman and designer cannot be overestimated. Since the object of the student is to learn *to draw*, and, in a measure, to obtain a knowledge of ornament, the above points are of

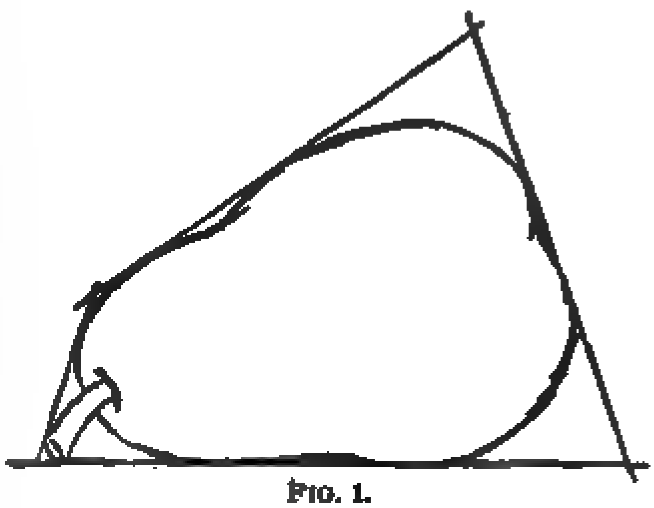


FIG. 1.

far greater importance to him than the mere act of repeating or copying of lines, and the purpose of this course is not to make copyists of the students, but to make draftsmen and designers of them.

The same spirit applies to the drawing of the *two halves* of any symmetrical ornament. Except in the main points of the design, no absolute identity of the two halves is to be attempted; there is no artistic necessity for such, either in drawings or in executed work. If some little inequalities appear in the two halves of some scroll or foliage work, *leave them alone* and remember that good ornament is enhanced in value, rather than depreciated, by the absence of constraint or of stiff regularity. The individuality of the designer, carver, or painter shows itself in such matters, and gives character to his work.

There is another very important point to be observed in the drawing of symmetrical figures. Never draw one half complete by itself and then the other half; lay the whole ornament out *as one figure* and finish it up simultaneously. Above all, *never trace off* one half of an ornament to produce the other half. This method of working is permissible in offices and shops, on the part of experienced draftsmen, and will be explained in future work, but must be *absolutely avoided* by the student in freehand drawing. Let him remember that he is learning *to draw*, and nothing will train either hand or eye as well as constant practice and redrawing the same thing.

6. While the use of drawing instruments and mechanical appliances is necessary in blocking out the preliminary work of any design, the design itself must in nearly all cases be executed freehand, or at least partially so. For this reason, the work in this course will be entirely freehand. The student is urged to practice constantly on other work than these plates, so that his hand may become subtle and his style systematic and individualized.

In freehand drawing, the work may be executed with one of several materials, as explained below, but only three

methods will be considered herein, as these three are the ones most frequently used and the only ones necessary except in special cases. The most common method of drawing is with lead pencil, and the object is either drawn in outline, as indicated at (*a*) and (*b*), Fig. 2, or shaded as at (*c*). If an outline drawing, the object may be expressed in lines conforming to the actual contour of the object itself, as at (*a*), or it may be drawn as it appears to the eye, as at (*b*). In

(a) (b) (c)

FIG. 2.

the former case the drawing is called an *elevation* of the object, and the latter is a *perspective* view.

Now, though the elevation of an object is of vast importance to the designer, he rarely expresses an object that way in design; unless the character of the work actually demands it—for instance, where the design is of a vase or pitcher that is to be *thrown* or *spun* in metal, it is sometimes necessary that the spinner should have an elevation of the object in order that he may spin it to the proper outline; but, where a design is to be reproduced by printing, weaving, carving, etc., the original drawing represents the design just as the reproduction is to appear. Elevations are usually drawn mechanically, while perspectives are in nearly all cases executed more or less freehand. Mechanical drawings are executed to scale, or in exact proportion according to measured dimensions. Freehand drawings are executed entirely with the unaided hand, and measured by the judgment of the

eye. The expert designer uses eye measurement almost exclusively, and the student is here advised to pay particular attention to this branch of his study, as it will be indispensable to him hereafter.

Drawings are also executed with pen and ink, in which case the general appearance is the same as in pencil; the method of execution is different, however, as will be explained later on. In fact, in the majority of cases a drawing is outlined in pencil, and then inked over and shaded with the pen.

The third method of drawing, described in this course, is with the brush. This is the method used most extensively by all designers. Its use is limited to freehand work, but its application is extended to designs in color and mezzotint.

THE PLATE EXERCISES.

7. The plates are to be drawn on the same size of paper (14 in. × 18 in.) as was used in *Geometrical Drawing*. The student should draw each of the exercises several times before he attempts the plate he will send in to the Schools for correction, as these plates are considered examinations to determine how carefully the student has studied the text and practiced his exercises. This preliminary work need be drawn in pencil only, on a good quality of brown paper that will withstand rubbing. Draw all the figures of one plate and complete it before beginning to ink it in, and do not attempt to ink it until you have practiced inking on separate pieces of paper. For fine lines in freehand work, use a Gillott's No. 404 pen, in a smooth, round, long holder without swell or taper. For heavy lines a coarser pen should be used. In regard to curves, it is generally best and easiest to ink them freehand, but in some cases, which will be pointed out as we progress in the work, they may be inked with instruments by combining arcs of circles with the lines of irregular curves.

When inking, keep the hands and tools clean, wipe the pen

LINEAR E

E

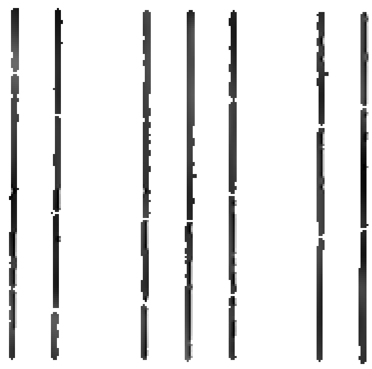


Fig 1

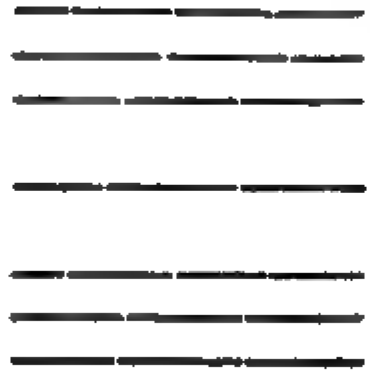
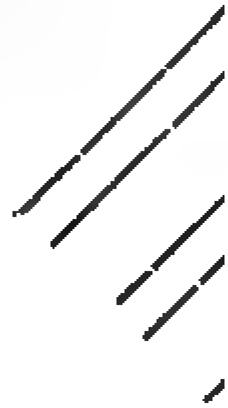


Fig. 2.



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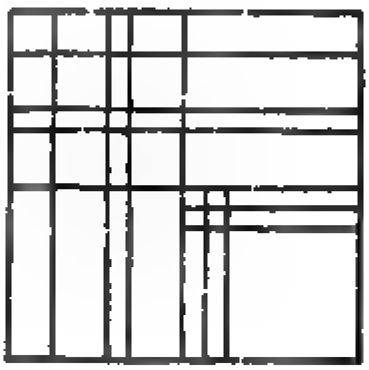


Fig. 6

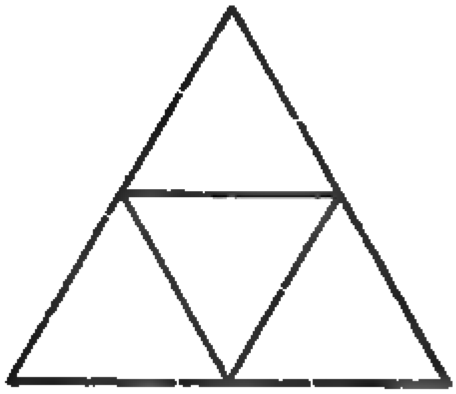
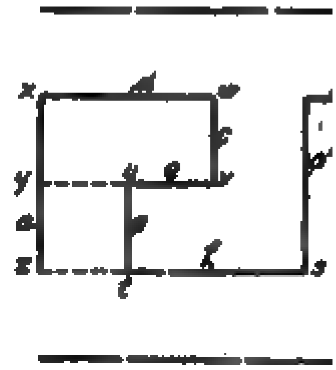


Fig. 7.



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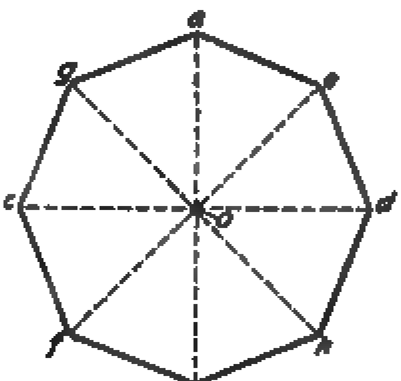


Fig. 11.

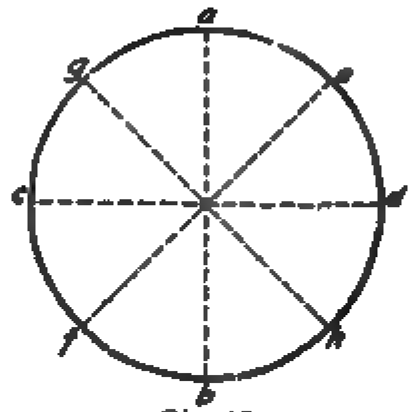
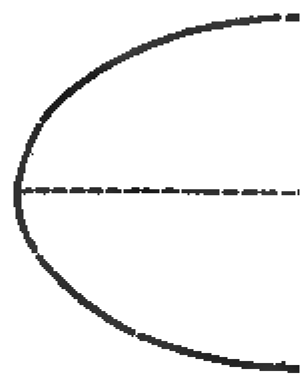


Fig. 12.



Fi

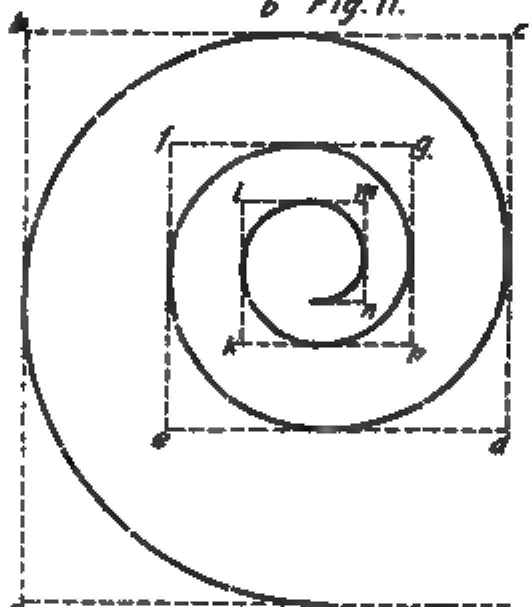


Fig 16

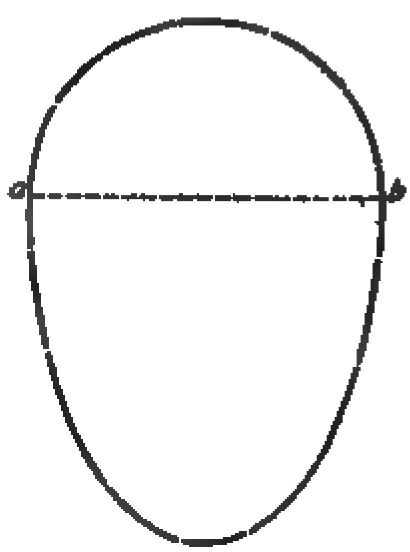


Fig. 17.

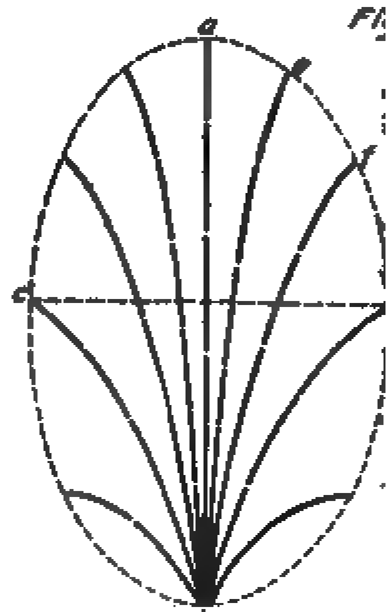


Fig. 18.

ELEMENTS.

Fig. 3.

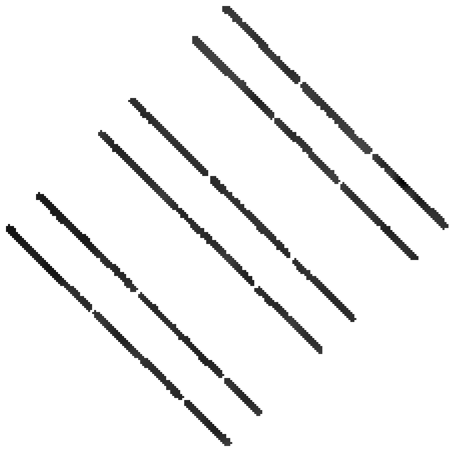


Fig. 4.

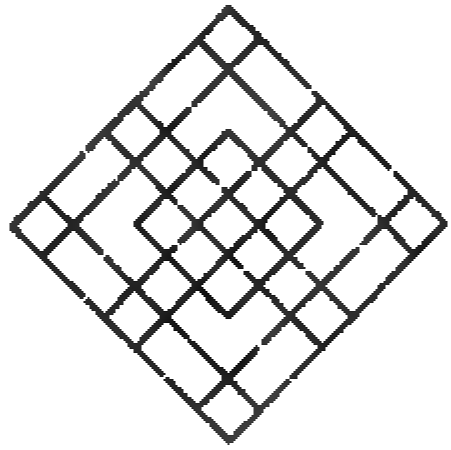


Fig. 5.

F

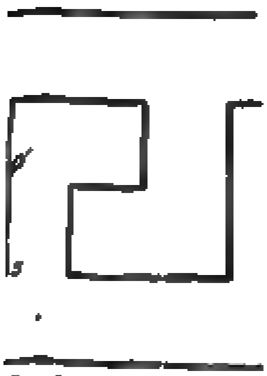


Fig. 8.

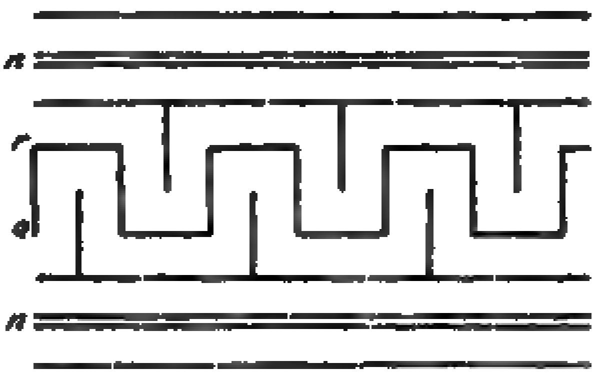


Fig. 9.

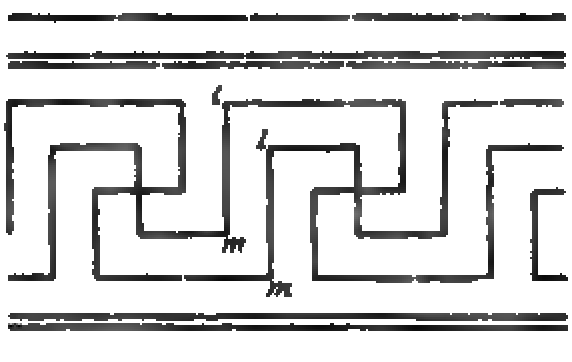


Fig. 10.

D

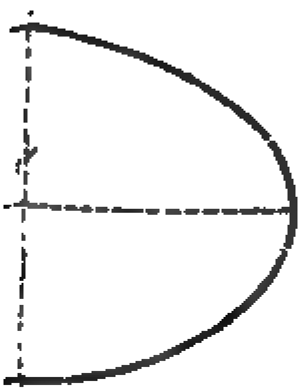


Fig. 13.

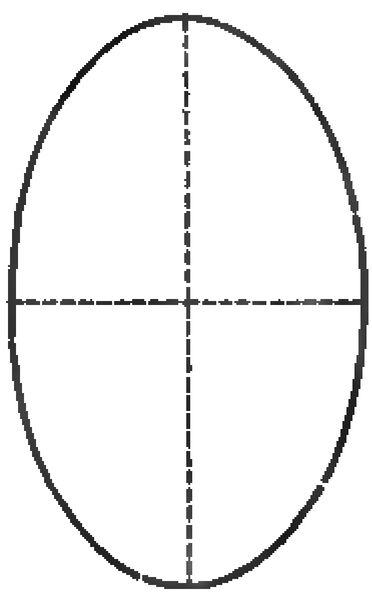


Fig. 14.

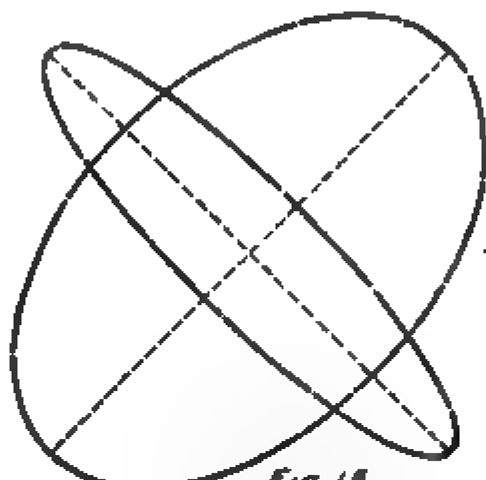


Fig. 15.

B

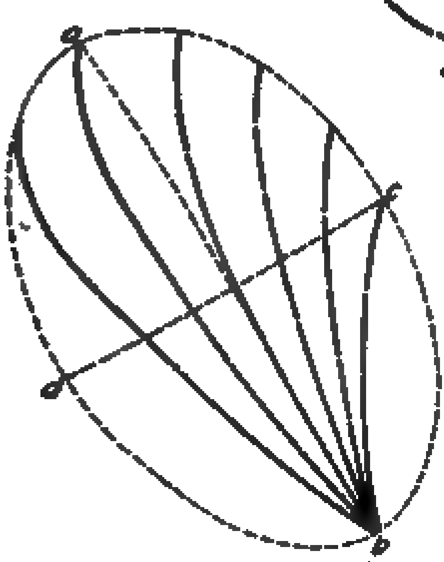


Fig. 19.

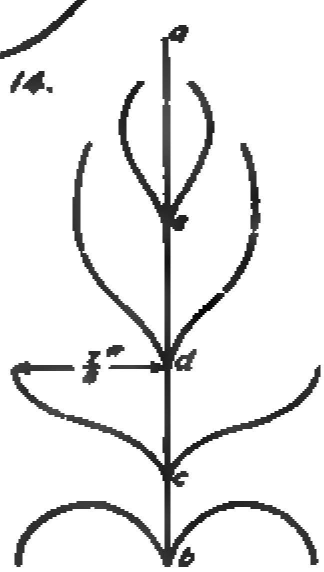


Fig. 20.

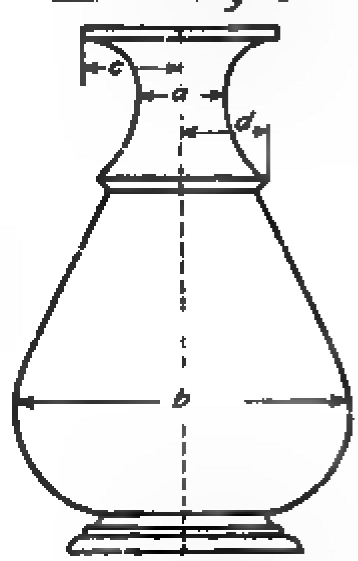


Fig. 21.

clean before each dip into the ink, and keep the bottle corked to exclude dust. When using stick India ink, ground on a slab, occasionally add a drop of water to keep it of equal shade and fluidity. The prepared ink provided with the designing outfit will require no diluting if it is kept constantly corked.

8. To the Student.—We realize that this work goes out to young men and women of varying degrees of ability, diligence, and opportunity; the exercises that will appear simple to one will prove difficult to another. To those of decided natural ability, we say: "Be diligent; keep at it in the regular order; do not think too soon that you know it all, or that you can disregard our instructions, or become careless." To those others whom nature has not so kindly endowed, but who have an earnest wish to learn, we say: "Be not discouraged by early difficulties; you are learning every day; your hand is becoming more supple and your eye more observant with each new exercise; try to realize that you are studying not only a useful, but an artistic, and also a difficult accomplishment, something worthy of your greatest efforts and unswerving perseverance. These staying qualities, joined to but a medium grade of talent, often succeed where greater abilities, joined to indolence and restlessness, result in failure. It sometimes takes years for the child to learn to write, but he finally learns, while the adult, better appreciating the value of the accomplishment, may acquire the same knowledge in a few months. Patience, perseverance, and constant practice are necessary in all cases, and *he who can learn to write can learn to draw*, as the principle is the same in both accomplishments."

DRAWING PLATE, TITLE: LINEAR ELEMENTS.

9. This drawing plate consists of 21 figures, each of which the student should be able to execute perfectly without other aid than the directions herewith given. The succeeding plates will each contain some detail or element, the

instruction for which can be traced back through the preceding plates to this one. *It is absolutely necessary, therefore, that the student should be perfect in every detail of each plate before attempting the next one.* The figures on this plate are simple lines and combinations of lines to produce some of the elementary forms that enter largely into all classes of design.

The exercises on this plate are to be drawn by the student to train his eye and hand to work together, and thereby become sufficiently practiced to execute the problems that follow. The drawing of a single line is of as much importance as the execution of an entire design, and the student must practice constantly and patiently, until he masters each simple problem, before he attempts the next. If each lesson is thoroughly learned, the next one will invariably prove easier.

In Fig. 1 of the plate is shown the method of drawing perpendicular straight lines. The pencil should be held lightly between the thumb and forefinger, with its upper end resting against the finger between the second and the third joint, while the end of the middle finger rests on top of the pencil alongside of the forefinger, and not underneath the pencil, as is sometimes erroneously done in writing.

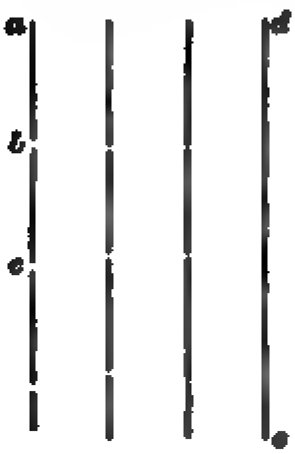
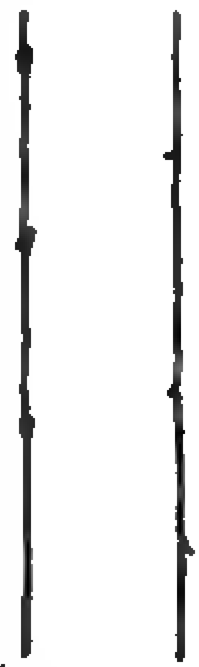


Fig. 2.

The drawing board should be squarely in front of the student, and his elbow should rest near the bottom of the board, somewhat to the right of the drawing on which he is at work. A short straight line is then drawn, as from *a* to *b* in Fig. 3, and the arm shifted a little lower down on the board, and another line, as *b c*, drawn, care being taken that there is a space of at least $\frac{1}{32}$ inch between the end of the line *a b* and the beginning of the line *b c*. A third section of the line is then drawn from *c* downwards, and so on, until the line is of the desired length. Having practiced this several times, the student should gradually decrease the spaces between the sections of the line until it appears as a straight

unbroken line, as shown at *d e*. It is necessary to be still more careful in doing this, lest the lines overlap one another or curl out at the ends. The former error causes the finished line to appear somewhat as at (*a*) in Fig. 4, while the line composed of strokes whose extremities are curled would appear ragged, as at (*b*). The strokes with which these lines are made are not short, quick dashes of the pencil or pen, but slow, even marks, each of which is started carefully, drawn slowly, and finished abruptly, so as to show a clean, even stroke, the same weight and color throughout, and clean cut from end to end. The second stroke must never lap over the first, and it is better to let a hairbreadth space remain between the ends of the lines than to have the least suggestion of a line like (*a*). Practice this simple line exercise repeatedly as in it lies the whole key to successful freehand drawing. When the student has acquired proficiency in this exercise, he may commence work on his drawing plate. Draw the border line enclosing a space 13 in. × 17 in., and then draw three light horizontal pencil lines *A B* 5 inches, *C D* 7 inches, and *E F* 9¾ inches above the lower border line. This will divide the drawing plate into four horizontal bands.



(*a*) (*b*)

FIG. 4.

Divide the length of one of these bands into five equal parts, and through the points of division draw light vertical lines, thus converting the surface of the drawing plate into twenty rectangles. This may all be done with the T square and triangle; but, from this point on, the student must abandon the use of instruments for this plate, and execute the problems freehand. Each figure, except Figs. 17, 18, 19, and 20, must be drawn as nearly as possible in the center, between the vertical lines of its respective rectangle, and each figure, except Figs. 11 to 15, must rest on the lower horizontal line of its rectangle. Now draw the first figure of the drawing plate. This consists of seven perpendicular lines, each of which is 2 inches long and spaced as shown, either ¼ inch or

½ inch from its neighbor. Only one of them need be an absolutely solid line, the others being composed of dashes about ¾ inch in length.

The drawing of horizontal lines should now be practiced in a similar manner, except that the elbow should be drawn nearer the body. When the strokes forming the horizontal lines are drawn, the whole arm should be moved toward the right, in order to prevent the lines from becoming arched, as would be the case if the elbow remained fixed and the hand were moved only so far as the swing of the arm would permit. The strokes forming the horizontal lines may be somewhat longer than those composing the vertical lines, but the method of forming one straight line, by the careful union of several smaller ones, remains precisely the same for both cases.

In drawing the horizontal lines, see that perfect parallelism is maintained; the spacing between the lines, however, may be gradually increased or decreased in order to better train the eye as well as control the hand. In drawing Fig. 2 of the drawing plate make the upper and lower three lines ¼ inch apart, and ½ inch from the middle line, all the lines being 2 inches long.

Figs. 3 and 4 show two sets of parallel oblique lines, the former being drawn from right to left, and generally called *right-oblique* lines, and the latter drawn from left to right, and usually designated as *left-oblique* lines. Fig. 3 is much the easier to draw, as the slope of the lines corresponds in direction to the inclination of the letters in ordinary handwriting, and the hand is more accustomed to the angle. After practicing the right-oblique lines until the student feels assured he can do as well with them as with the two previous sets, he should draw a series in the direction shown in Fig. 4. To do this it will be necessary for him to change the position of his arm, so as to bring the elbow toward the right end of the board and the hand above, and to the right of the lines to be drawn. The lines in Figs. 3 and 4 should incline at an angle of 45°, and should be arranged in pairs, as shown, with ¼ inch between the individual lines of each

pair, and a distance of 2 inches between the extreme outside lines of each figure, the lines each being 1¾ inches long.

Figs. 5 and 6 involve no new principle in drawing, and are simply a combination of the previous problems. Observe, however, that though these two figures contain exactly the same number of lines and nearly the same lengths of lines, they are, in appearance, entirely different. This difference of appearance is due to the *composition* of the figures, and many changes of arrangement can be effected without altering the number or size of the lines. In line composition the designer has but two elements to consider—the lines and the spaces. Subsequently he may darken some of the spaces,

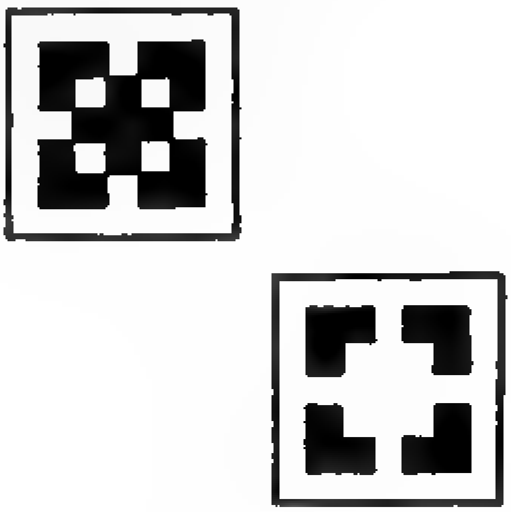


FIG. 5.

thereby entering into surface composition, wherein he has at least two more elements to consider—*light* and *shade*. Fig. 5 of the text shows six different problems in composition, all based on the line elements as arranged in Fig. 5 of the drawing plate, but treated differently as to light and shade, thus illustrating the fact that even with a few elements of composition a great variety of design may be produced. The blackening, or shading, of certain parts of a line composition, in this manner, is technically termed *spotting*, and when a plain line drawing is thus treated it is said to be *spotted*.

To draw Fig. 5, first erect a perpendicular line in the center of the last rectangle, and from its intersection with the line EF, draw right and left oblique lines each at an angle of

45°, and $1\frac{5}{8}$ inches in length. Let these two lines be the lower sides of a square standing on its corner. Having completed the square, draw $\frac{1}{4}$ inch within each of its sides, a line parallel to that side, and through the center of the square draw parallel lines $\frac{1}{4}$ inch apart, as shown. The small inscribed square may then be drawn, each side of which is $\frac{3}{4}$ inch.

The square enclosing Fig. 6 is 2 inches on each side, and rests on the line CD directly below Fig. 1. The lines of its composition are spaced $\frac{1}{4}$ inch, $\frac{9}{16}$ inch, $\frac{11}{16}$ inch, 1 inch, $1\frac{3}{8}$ inches, and $1\frac{3}{4}$ inches from the left side and top, respectively. The same number of lines and nearly the same lengths of lines are used in both Fig. 5 and Fig. 6, but, as said before, the student can readily see the variation of effect that may be obtained by the simple arrangement of a few lines.

The exact sizes and dimensions of the several interior squares are not matters of importance to us now, and the student's drawing of this figure will be judged by the care of his execution rather than by the accuracy of his eye measurement. The angles of the square must be 90°, and not more nor less, and opposite sides must be perfectly parallel, while adjacent sides must be perpendicular to each other. The straightness of the lines or their exact length as to this description will not be considered. For instance, a drawing like Fig. 6 of the text would be considered as satisfactory at this stage of the work, for, though the lines are somewhat irregular, their directions are correct and they intersect at right angles; and though the inner rectangles are larger than the corner ones, they are perfect squares and are all the same size one as another. They thus preserve harmony in the figure and avoid the appearance of irregularity and carelessness shown in Fig. 7, wherein the lines themselves are more nearly perfect but their direction and parallelism extremely faulty. Draw Fig. 5 several

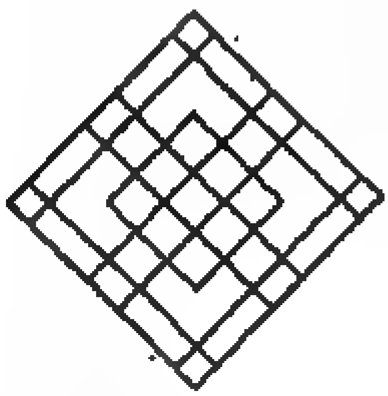


FIG. 6.

times on a separate piece of paper before executing it on the drawing sheet.

These simple line exercises are of the utmost importance to the student, as on them will depend much of his future freehand work. He should practice each set repeatedly, on a sheet of ordinary brown Manila paper, until he feels confidence in his ability to produce, at will, perpendicular, horizontal, or oblique lines, and then, *but not till then*, should he attempt to draw them on the sheet that he will send to the Schools for correction. Each of these exercises should be drawn as carefully and as accurately as though it were a part of a complicated design. Haste will only produce slovenliness and impede the progress of the student to the end he seeks to attain, namely, that of becoming a good draftsman. *Neatness*, *accuracy*, and *rapidity* are the three qualifications of a good draftsman, in the order of their importance, and the last is of no value unless accompanied by the other two, while the second is impossible without the first.

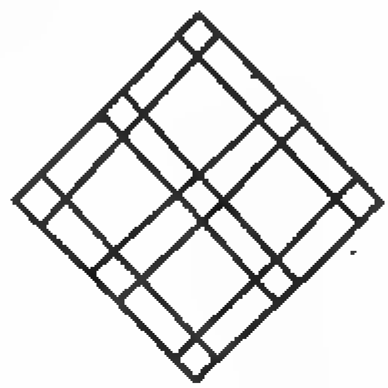


FIG. 7.

Fig. 7 is an equilateral triangle, the base of which is 2½ inches long. The inclination of the sides is not so easy to judge by the eye as were the 45° lines in Figs. 3, 4, and 5, but if the student will bear in mind that the apex must be exactly over the center of the base, he will experience little trouble.

After the triangle is drawn, bisect the sides and draw the enclosed triangle as shown.

The triangle is a very important figure to the designer of certain classes of goods, such as wall papers, carpets, etc., as the facility with which it can be repeated, and still retain its original form, makes it extremely valuable as the guiding principle of several classes of patterns.

Figs. 8, 9, and 10 are examples of borders taken from Greek pottery, and are composed entirely of straight lines, that when *spotted*, as explained in connection with Figs. 5

and 6, can be made very interesting and complicated. For instance, on looking at Fig. 8 of the text we observe that the pattern consists of two outline forms identical in every respect, and so shaped that one fits exactly into the other, that the lines a are all of the same length and at right angles to each other, and the lines b are all twice the length of lines a.

FIG. 8.

For Figs. 8, 9, and 10, the student may draw with his T square three horizontal lines at x, y, and z, about $\frac{1}{2}$ inch apart, and extending through the three right-hand divisions of the sheet. Fig. 8 is then executed by drawing a vertical line $x z$ across the three lines thus ruled; and at a distance to the right of this vertical, equal to the space between the horizontals, another vertical line $u t$ is drawn between the two lower horizontals. A third vertical line $w v$ is then drawn the same distance to the right of the second one, and extending between the upper two lines. The horizonal lines $x w$ and $u v$ are then drawn, connecting the ends of $x z$ and $w v$, and $w v$ and $u t$, as shown, and with $t s$ equal to $x w$ the outline of one of the sections of the fret is complete. The vertical line a', drawn to the right of $w v$, will then start a second section of the fret, and, at the same time, complete the inverted outline that is to follow the contour of the first section. A peculiarity of all the best Greek frets is that the outline of the fret and the outline of the background are identical, as shown in Fig. 8. Having drawn the meandering outline of the fret, draw the horizontal border lines above and below, so as to make the whole design about 2 inches wide, and erase the pencil lines x, y, and z where they have not been inked in.

Fig. 9 is somewhat similar to Fig. 8, but is capable of more variations in *spotting*, as shown in Fig. 9 of the text. At (a) we have the ground and the pattern of the fret spotted in contrasting colors, while the effect at (c) is produced simply by increasing the weight of the constructive lines. Both systems

produce frets wherein the ground and pattern are similar in outline. At (*b*) the line of separation between the dark and light portions of the design is thickened into a white band and the other elements are left in black. To design Fig. 9, a number of perpendicular lines are drawn across the center line *y* equal in length and spacing to the distance between the three horizontal guide lines *x*, *y*, and *z*. The tops *r* and bottoms *q* of each alternate pair of the verticals are then connected with a horizontal line equal to the verticals. This forms the meandering outline of the figure. Above and below this meandering outline, at a distance equal to half the space between the lines, two horizontal lines are drawn, from which perpendiculars extend into the open parts of the meander as far as the middle horizontal guide line *y*. The border lines above and below are then drawn to make the entire width about 2 inches.

FIG. 9.

Fig. 10 is more complicated. It is a combination of Figs. 8 and 9, and, when analyzed, shows two entirely separate and distinct but identical outlines so interwoven as to form one harmonious design. This design may be made very complicated by *spotting*, as shown in Fig. 10 of the text. To design Fig. 10 of the drawing plate, the simplest method is to draw across the central guide line a short vertical line equal in length to the verticals in Fig. 9; then, through the center of this vertical, draw a horizontal line of the same length, thus forming a simple cross, *a b*, *c d*, Fig. 11 (*a*). Now, from

the upper and lower ends of the verticals, draw lines of equal length to the left and right, respectively, and from the left and right of the horizontal line draw at right angles a line extending below and one above the center guide line and equal in length to the other lines drawn; this will produce a figure similar to Fig. 11 (*a*). Now draw a third set of lines at right angles to this second set and parallel to the first set, as shown in Fig. 11 (*b*). These lines, it will be observed, are the same distance apart, and are exactly parallel. The horizontal lines at the top and bottom may now be extended to left and right, respectively, a distance equal to the space between parallel lines of the meander; this will complete one section, and the same operation may be repeated, making the intersections of the short cross-lines take place at a point five times the space between the horizontal lines to the right.

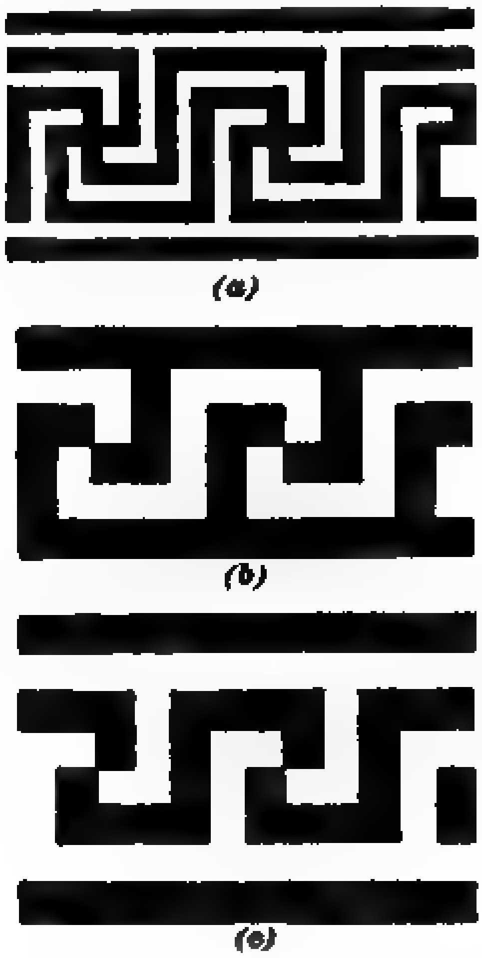


FIG. 10.

Fig. 11 is a simple octagon, but to draw it accurately requires more care and accuracy of eye measurement than any of the previous figures. Begin it by drawing a perpendicular line *a b*, 2 inches in length, and extending 1 inch each side of *A B*. Carefully lay off the length of *c c*, 1 inch each side of *a b*; *e f* and *g h* are now drawn at an angle of 45° with *a b*, and intersecting it at its center *o*. From *o*, carefully lay off 1 inch on each of the oblique lines, as its length each side of the center. If this work is accurately done, the lines connecting *a e*, *e c*, *c h*, etc.

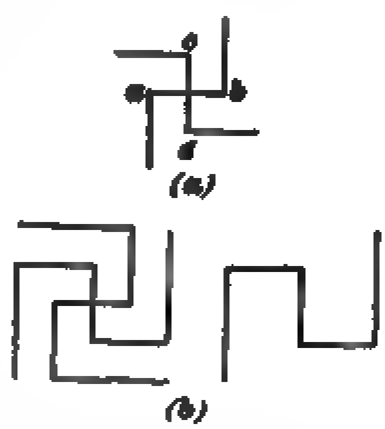


FIG. 11.

will describe a perfect octagon. Study it carefully, and if any signs of unevenness are observed, alter the outline and correct the point.

Fig. 12 is a circle, and it is drawn in precisely the same manner as the previous figure, except the points *a e*, *e d*, etc. are connected with curved lines instead of straight ones. In drawing the circumference of the circle, after the guide lines have been carefully laid out, a short straight line may be drawn across the ends of each of the guide lines, as shown in Fig. 12 of the text at *a*; then between each pair of these short lines, another short line may be drawn, producing a 16-sided polygon; the whole circumference may then be evened up as at *b* before it is inked in. Considerable practice is necessary to enable the student to draw a perfect circle, but he will be surprised and delighted to learn how simple a problem this is after careful and repeated practice.

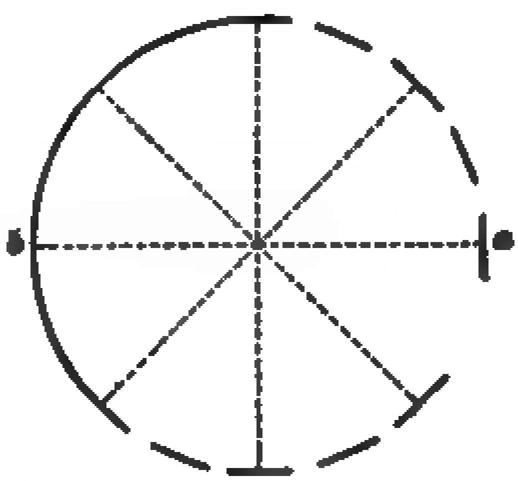


FIG. 12.

Figs. 13, 14, and 15 are ellipses whose major and minor axes intersect on the line *A B*. The three large ellipses in these figures are each $3\frac{1}{4}$ inches long and 2 inches wide, and the fourth one intersecting the large one in Fig. 15 is $3\frac{1}{4}$ inches long and $\frac{3}{4}$ inch wide.

The method of drawing an ellipse geometrically was explained in *Geometrical Drawing*, so the student should be, by this time, fairly familiar with the characteristics of the curve. First draw the two axes, then draw short straight lines at right angles to the ends of the axes, and roughly sketch in the curve, in pencil, as shown in Fig. 13 of the text. Care must be exercised, however, to keep the proper curvature and avoid such appearing sketches as shown in Fig. 14. The student himself can see that these are not ellipses, and must avoid returning his drawing plate with any such monstrosities. This

is a difficult figure to draw, but with proper care and practice it can soon be satisfactorily rendered. The con-

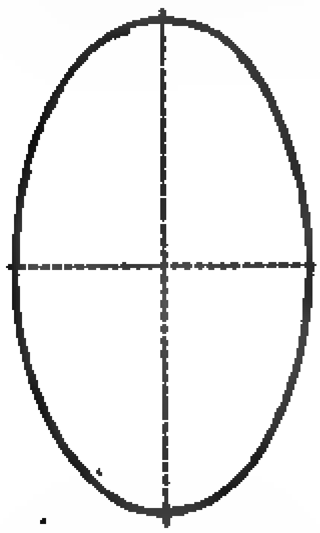


Fig. 13.

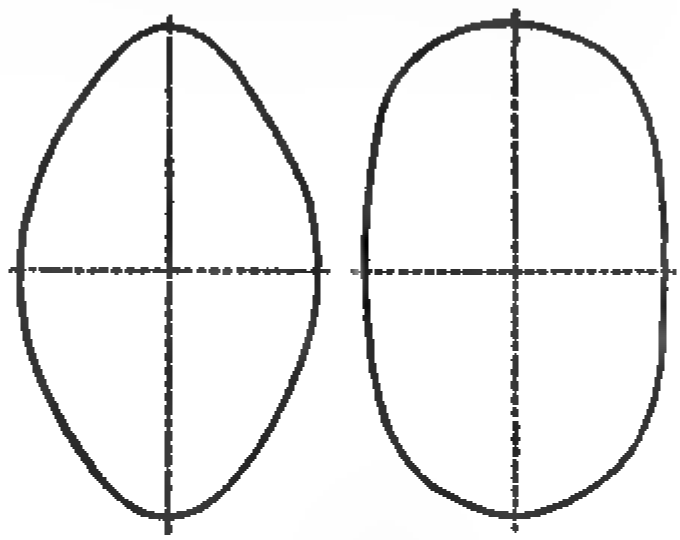


Fig. 14.

struction lines of Figs. 11 to 15 should be drawn and inked freehand.

Fig. 16 is a volute more commonly known as a spiral, and its outline in varied forms pervades all styles of ornament. It is, therefore, worthy of considerable attention. The example here given is purely Greek in its proportions, and the ratio of its height to its width is governed by definite geometrical rules for each convolution or turn.

In drawing the Grecian volute, the construction lines ab, bc, and cd should be laid out in the proportion of $6\frac{1}{2} : 5\frac{1}{2} : 4\frac{1}{2}$. That is, if ab is $6\frac{1}{2}$ inches long, then bc and cd must be $5\frac{1}{2}$ inches and $4\frac{1}{2}$ inches, respectively. And the construction lines of the inner convolution must have this same proportion; that is, $ef : fg : gh = 6\frac{1}{2} : 5\frac{1}{2} : 4\frac{1}{2}$.

To draw Fig. 1, lay off $ab = 3\frac{1}{4}$ inches, $bc = 2\frac{3}{4}$ inches, and $cd = 2\frac{1}{4}$ inches; ef is always $\frac{1}{2}\,ab$, and de is $\frac{1}{2}(cd + ef)$; therefore, ef is $1\frac{5}{8}$ inches, and de is $\dfrac{2\frac{1}{4}+1\frac{5}{8}}{2} = 1\frac{15}{16}$ inches; de is, therefore, laid off $1\frac{15}{16}$ inches and ef $1\frac{5}{8}$ inches; fg will be in proportion to ef as $6\frac{1}{2} : 5\frac{1}{2}$, or $1\frac{3}{8}$ inches, and gh will be to fg as $5\frac{1}{2} : 4\frac{1}{2}$, or $1\frac{1}{8}$ inches. In the same manner hk is found to be $\frac{31}{32}$ inch, kl is $\frac{13}{16}$ inch, lm is $\frac{11}{16}$ inch, and mn is $\frac{9}{16}$ inch. Within these construction lines (*which must be accurately laid off with the scale, and drawn with the*

T *square and triangle*) the volute is then drawn freehand, care being exercised that the curves are just tangent to the straight lines as they pass. After inking this volute curve, the student should dot in the construction lines with a ruling pen.

Fig. 17 is an *oval* and is composed of a semicircle and a semiellipse whose major axis is located 4¾ inches from the left border line. Draw freehand the line *a b* 2 inches in length and 2½ inches above the lower border. Above this line construct a semicircle in the same manner as was done in Fig. 12, using *a b* as its horizontal diameter, and below construct a semiellipse after the manner practiced in Figs. 13, 14, and 15, with *a b* as the minor axis which shall extend 2 inches below *a b*. The correct outlining of these elliptical curves is of vast importance in the exercises that follow, and the student is urged to practice them frequently.

Fig. 18, though simple in appearance, is by no means easy to draw. It represents the radiation of lines from a point, a characteristic of the growth of some plants, that is frequently taken advantage of in examples of ornamental design. To draw Fig. 18, first lay off the lines *a b* and *c d* as the major and minor axes of an ellipse (the former being 7½ inches from the left border line) identical with Fig. 14; then carefully outline this ellipse in pencil, and within it draw the radiating lines curved, as shown. Note that the radiating lines intersect the circumference of the ellipse nearer together at the top than at the sides, the distance *a e* being about ¼ inch, while *e f* and *f d* are about ⅜ inch and ⅝ inch, respectively. After inking the figure, the construction line *c d* may be erased, and the ellipse dotted in with the ruling pen and irregular curve.

Fig. 19 is drawn within an ellipse also, but the major axis *a b* is inclined at an angle of 60° and intersects the minor axis at a point 2 inches above the lower border line and 6¼ inches from the right border line. The curved lines radiate evenly from *b* and intersect the circumference in three points equally spaced between *a* and *c*. In inking this figure, the construction lines may be erased

and the elliptical curve dotted in with ruling pen from *c* to *a* only.

Fig. 20 is another example of radiation, but from a line in this case instead of a point. Draw *a b* 3 inches long and 4 inches to the left of the right-hand border line, and mark off thereon the points from which the curved lines radiate. Note that these points are not regularly spaced along *a b*, but that their distance apart increases toward the top. From *b* to *c* is but $\frac{1}{2}$ inch, while the distances *c d* and *d e* are $\frac{5}{8}$ inch and $\frac{3}{4}$ inch, respectively. The radials starting from *c* extend $\frac{3}{4}$ inch to the right and left of *a b*, and upward to the level of *d*. The radials from *d* extend $\frac{1}{2}$ inch to the right and left of *a b*, and those from *e* only $\frac{1}{4}$ inch. Their length and upward extent the student must judge by the eye, as also the two lower radials, which extend about $\frac{3}{8}$ inch each side of *a b*.

These radiating figures must be studied carefully; there is really very much more in them than would at first appear, and the principles of their composition and construction pervade all natural ornament.

The radiation of the lines in Figs. 18 and 19 is characteristic of the growth of some plants, such as the cattail, as shown in Fig. 15, and the veining of certain leaves as in Fig. 16 of the text. The radiation from a line, as shown in Fig. 20 of the drawing plate, is characteristic of the growth of

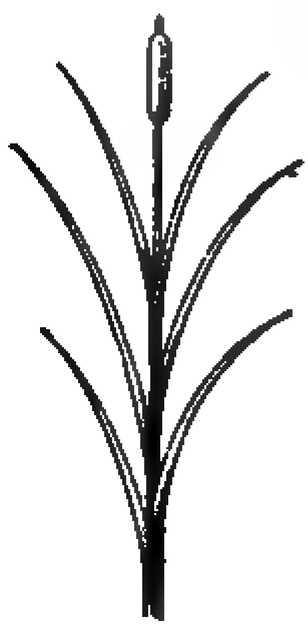


FIG. 15.

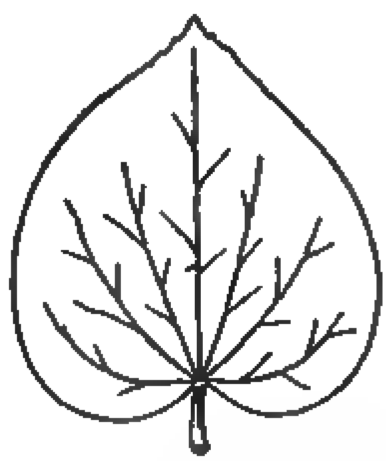


FIG. 16.

many trees and shrubs, and illustrates the great laws of all foliated ornament. These laws are based on the observation

of the arrangement and natural growth of plants, and are as follows:

1. *All lines should radiate from a parent stem.*

2. *All branching lines should be tangent to the line from which they branch*, as in Fig. 20, where the branching lines do not start out of *a b* abruptly, but are tangent to it at *c*, *d*, etc.

3. *There should be a proportionate distribution of areas.* This is not so easy to understand as the previous rules, but may be illustrated by a tree, wherein the areas are proportioned according to their distribution and distance from the parent stem. The trunk is the parent stem, and has the greatest area, but decreases toward the top. The branches nearest the ground are the largest and closest together, and diminish in size toward their ends. All branches and twigs are less in area than the branch from which they spring. In Fig. 20 observe that, though the parent stem and branches are single lines of equal thickness and apparent area, the arrangement is such as to give the impression of distribution. The area embraced by the lower branches is greater than that of the ones above, and the outline of the entire figure diminishes toward the top, giving an impression of lightness and solidity.

Always observe these rules in drawing any figure, and try to make the representation of an object appear lighter toward the top. Note that in all works of architecture, high structures, such as steeples and towers, are either made smaller toward the top, or are pierced above with large windows in order to give the appearance of lightness at the top and solidity at the bottom. Note that columns, pilasters, and piers are nearly always smaller at the top than at the bottom, thus expressing their immovability; while the legs of tables and other unfixed objects are smaller at the bottom than at the top, expressive of their movability.

In drawing Fig. 21, the student has simply to combine the details of a few of the previous problems. This figure is a vase 3 inches in height, and $\frac{1}{2}$ inch and $1\frac{7}{8}$ inches in diameter at *a* and *b*, respectively. The student will draw the center

line of the vase directly under the center of Fig. 15, and lay out the outline entirely freehand and by eye measurement. Knowing the dimensions *a* and *b*, the observing student will discover that *c* is a little more than *a*, and that *d* is a little less. Other dimensions can be judged by comparison in the same manner and the figure completed without further directions. After inking in Fig. 21 the construction line through its center may be erased.

Having completed all the figures in pencil, the student will proceed to ink them in freehand, except where the previous instructions directed him to do otherwise. He may then draw the title $\frac{5}{16}$ inch high at the top of the plate, freehand, and ink the border line with his ruling pen. In inking a drawing freehand, the pen is held in precisely the same manner as the pencil, and the lines are drawn carefully in short, even strokes, to preserve uniformity. Use a good, coarse pen, and do not be afraid to let the lines be rather heavy at first, as a thin line is more difficult to draw evenly than a heavy one. The name, class letter and number, together with the date, may then be inserted below the line, as in previous cases.

NOTE.—Do not ink in your drawing of this plate, or return it to us for correction until after your first plate is returned to you with its corrections and criticisms. Then note carefully the errors pointed out and see that similar ones have not been made on your Drawing Plate, title, Surfaces and Solids.

After we have called the student's attention to the errors on his first plate, we expect him to profit by the criticism and avoid a repetition of them on his second plate; as a repetition of the error will count against him more than when it was first made.

This method of procedure will be necessary throughout the entire course, as there are but two plates of each kind of work, and the student needs the criticism of the first in order to properly execute the second.

DRAWING PLATE, TITLE: SURFACES AND SOLIDS.

10. The figures on this plate consist of a series of objects, the drawing of which will involve all the principles learned in the execution of the previous plate. The first four figures are designs of surface ornament or details wherein the consideration of depth or thickness forms no part. The last

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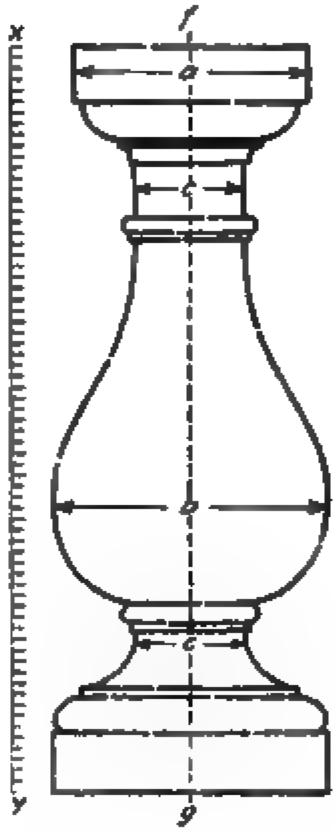


Fig. 1

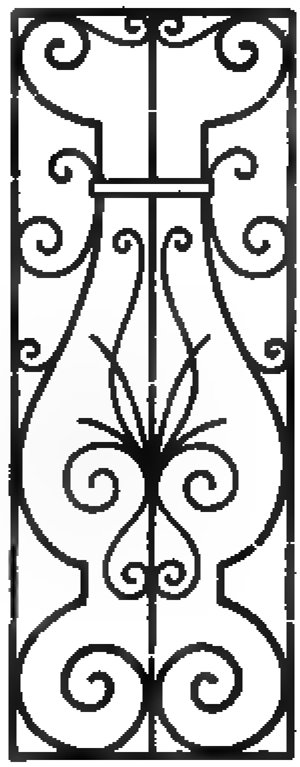


Fig. 2.

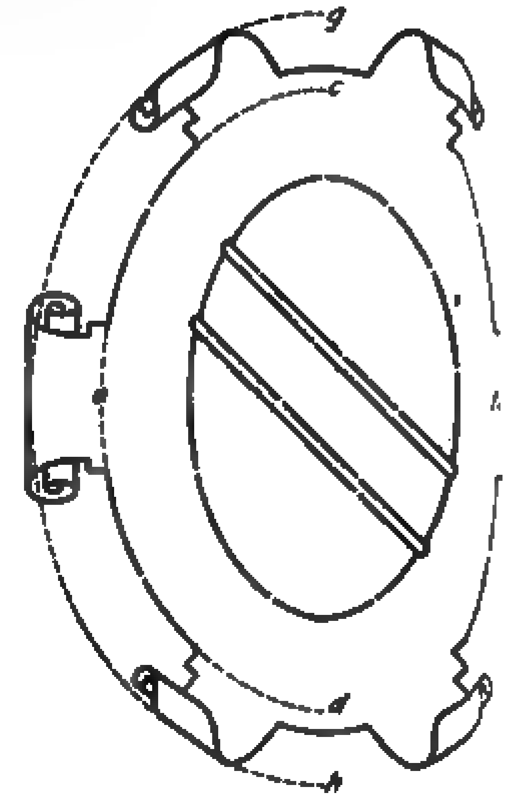


Fig. 3.

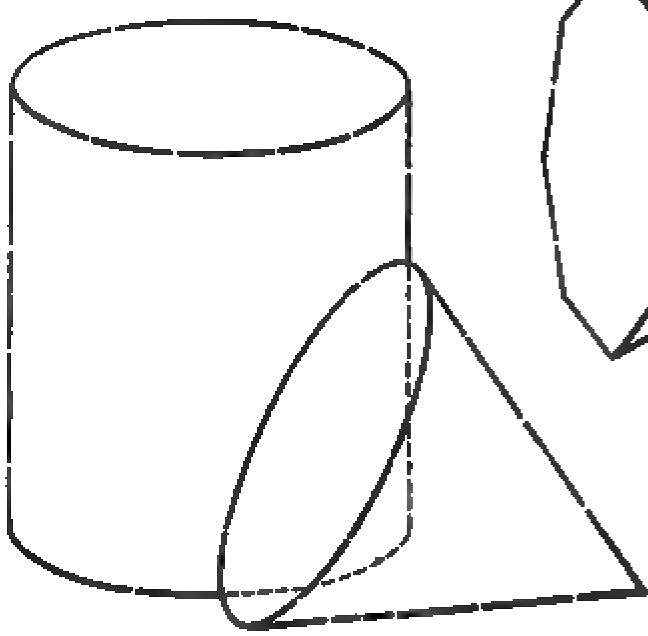


Fig. 5.

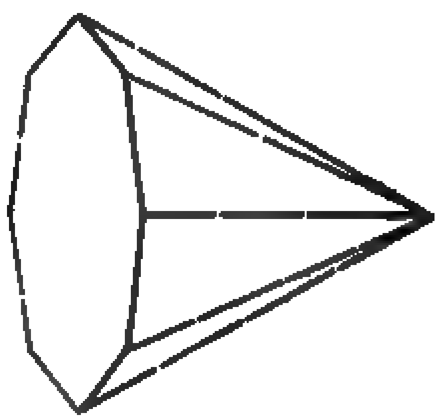


Fig. 6.

Fig. 7

SOLIDS.

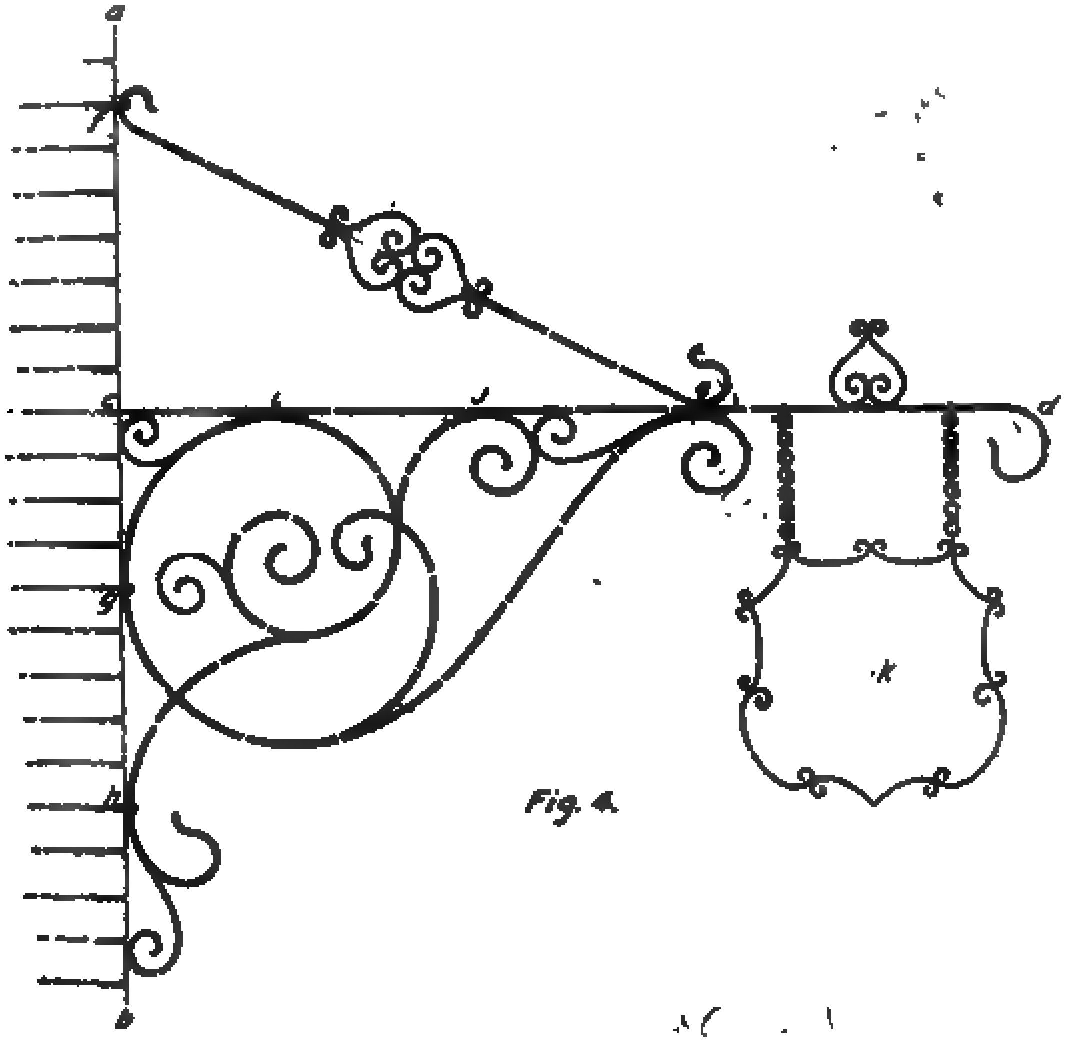
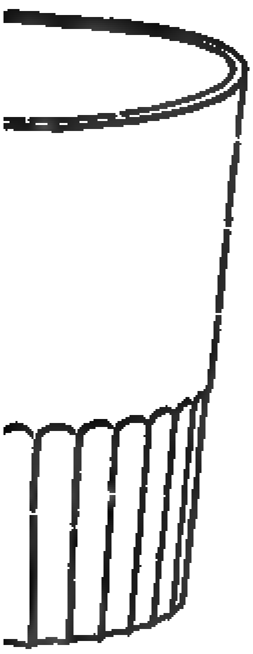


Fig. 4.



7.

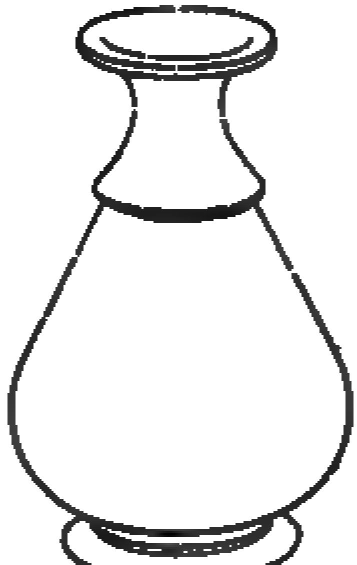


Fig. 8.

Fig. 9.

five figures are sketches in perspective of familiar objects drawn so as to accustom the student to the representation of objects where the dimension of thickness or depth must be expressed. In drawing this plate, lay out the border line as before and divide the plate lengthwise by a horizontal pencil line through the middle, and above this line divide the space as follows: Draw four vertical lines, 1¼ inches, 4 inches, 7¾ inches, and 11⅜ inches to the right of the left border line. The first three of these will be the center lines of Figs. 1, 2, and 3, and the fourth will be the line of the wall *a b*.

Fig. 1 is a baluster and its moldings, according to the architectural proportions set forth for such details. The student will first draw a vertical line *x y*, ¼ inch to the right of the border, to serve as a measuring line. This line will be divided into 68 equal parts, as shown, each part being $\frac{1}{16}$ inch, thus making the height of the baluster 4¼ inches. All the measurements for the proportioning of the baluster will be given in parts, each part being, as above stated, $\frac{1}{16}$ inch. The width of the abacus *a* is 22 parts, the thickest part of the vase at *b* is 25 parts, and the diameter of the neck at *c* is 10 parts. The vertical measurements can be determined by counting the number of parts between each division, and when all the horizontal lines are located the contour may be carefully sketched in. The vertical measuring line may then be erased before the figure is inked in. Although these proportions are subject to slight relative alterations under different circumstances, they are practically uniform in nearly all cases where the outlines of a stone baluster are required.

Fig. 2 is a panel of an iron railing the design of which consists of a series of scrolls and radiating ornament, based on the outline of the baluster just drawn, but changed to suit the circumstances required by working in strap iron, in contrast to the requirements of stone. The student's attention is called particularly to the fact that there is propriety in the ironwork design in making its outline resemble the outline of the solid baluster, inasmuch as it is to serve a similar purpose in a balustrade of different material.

The center line and enclosing rectangle of Fig. 2 may be

drawn precisely the same as in Fig. 1, except that the rectangle itself and the center line will be inked in solid, as it is intended to form a part of the ironwork. The center line is located 4 inches to the right of the border line, and the contour of the inside ironwork follows as closely as possible the contour of the stone baluster.

In Fig. 3 we have a design for another device in ironwork, but one of an entirely different character. Fig. 3 is a cartouch made of sheet iron, the design of which is based on the ellipse. *Cartouch* is the term applied to circular or shield-shaped devices, whose surface is represented in relief, and the border of which is usually more or less ornate with scrolls or strap work. In order that the student may understand the character of Fig. 3, he should give his attention to Fig. 17 of the text, which is a developed outline of the piece of sheet iron or other metal from which the cartouch would be made. The wings *a* are rolled backwards and the wings *b* rolled forwards, and produce the effect expressed in Fig. 3 of the drawing plate. The student should lay out the figure first, as shown in the text, and cut it out of heavy paper or thin metal, and then by rolling the wings around his pencil in the direction indicated, he can form a model of the device, which, set up before him, will greatly assist him in the representation on his plate. The length of the ellipse from *c* to *d* is $3\frac{1}{2}$ inches, while its breadth from *e* to *f* is $2\frac{1}{2}$ inches. The interior ellipse is $2\frac{1}{2}$ in. $\times 1\frac{1}{2}$ in., the circumference of which is practically parallel with the outside. After the wings have been rolled

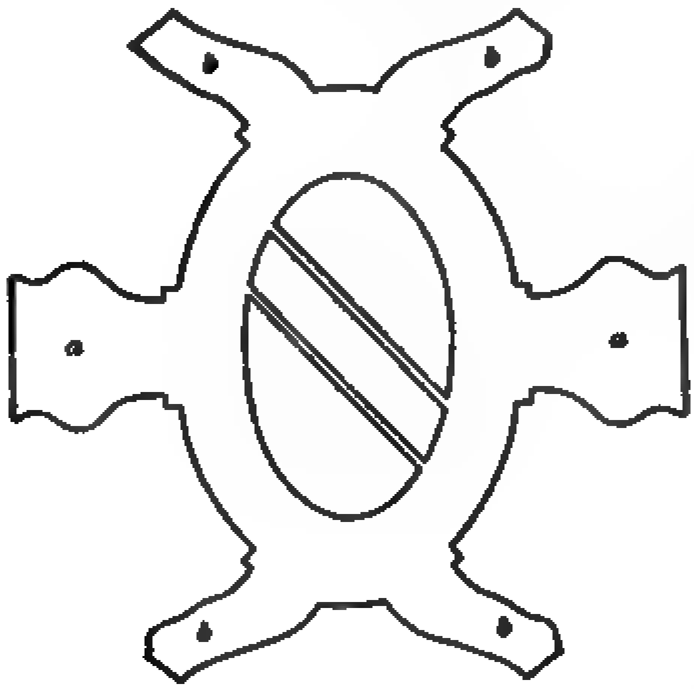


FIG. 17.

over, they project uniformly from the top and sides of the cartouch, so as to come within the outline of another ellipse shown dotted at *g h*. There is nothing difficult in the drawing of this figure, the ellipses being contoured in the same manner as on the previous plate, and the curled wings being represented by a simple combination of scrolls and straight lines. When the figure is completed, the student may erase all of the guide lines.

Cartouches are not only executed in metal work, but are often carved in stone or wood, or modeled in plaster or terra cotta. They are also sometimes drawn, as on this plate, as an ornament at the top, or in the center, of some certificate, or other paper of a documentary character. Its purpose, in nearly all cases, whether carved in stone or wood, or drawn or printed on paper, is to bear a device—either a number, a title, or a monogram. There are many forms of it, some being regular, as in this case, and others being irregular and eccentric, according to the purpose for which it is required.

In Fig. 4 we have an iron bracket, such as is used in many foreign cities as a sign hanger. It consists of plain straight iron rods bent into scrolls, combining beauty of curve with utility of purpose. The main rod of the bracket *c d* is $5\frac{1}{4}$ inches long and $2\frac{3}{4}$ inches below the upper border line. At *e*, $3\frac{1}{4}$ inches from *c*, a hanger extends to the main wall at *f*, $1\frac{3}{4}$ inches above *c*, while from the same point *e* on the under side of the rod *c d* the main scroll springs and becomes tangent to the wall at *g*, 1 inch below *c*. The branch scroll is tangent to the wall at *h*, $2\frac{1}{4}$ inches below *c*, and the other tangent points at *i* and *j*, $\frac{3}{4}$ inch and 2 inches to the right of *c*, respectively. The other curves of the scroll, and the small ornamental scrolls on the top and sides of the main bar and hanger, can be proportioned and drawn by the eye, altering and shifting them as the circumstances may dictate. The sign itself hangs below the bar within a rectangle $1\frac{1}{2}$ inches square, the center of which is at *k*, $4\frac{1}{4}$ inches to the right of the wall and $1\frac{1}{2}$ inches below the bar *c d*. The rectangle containing the sign should be drawn in place and the sign itself then sketched within it. After the figure is inked,

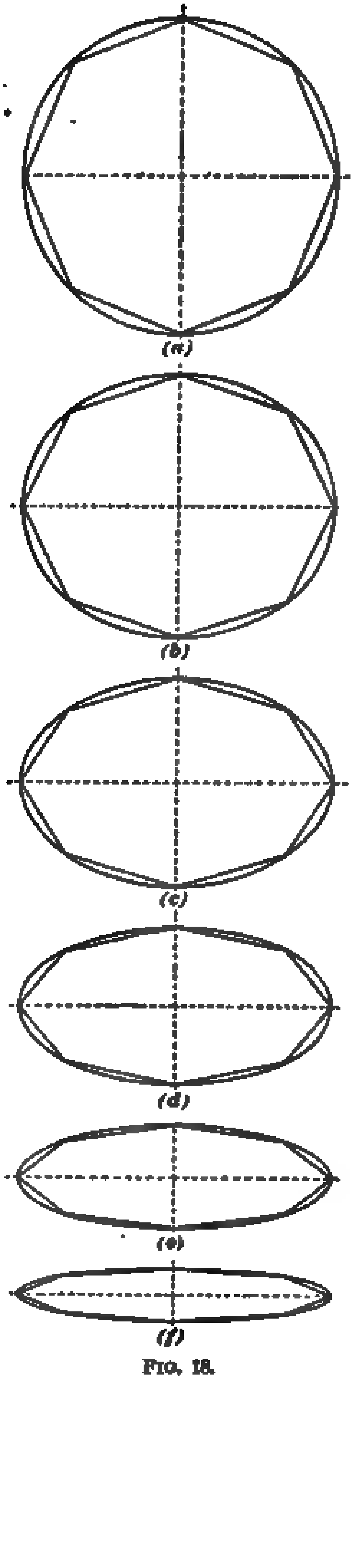


FIG. 18.

all of the guide lines should be erased. The student should take plenty of time and pains in drawing this figure, as its style is not only useful for many devices and designs, but the same design will be used again in this course to illustrate an advanced branch of ornamental ironwork. Not only are hanging signs of this character used over doors and on posts to indicate a public inn or other announcement, but they are frequently used on designs for menus and other occasional cards as a device on which to place the date, or a title, or even the initial letter of a sentence.

The next five figures on this plate will be sketches of objects in perspective, and, while it is not the intention in any part of this course to teach the theory of perspective drawing, there are a few simple details concerning perspective representation that are not only useful, but in some instances of design positively necessary. In the first place, the appearance of a circle in perspective is always elliptical, and when the student draws an ellipse, either mechanically or freehand, he represents thereby the perspective view of a circle. The student should practice frequently the drawing of ellipses of different sizes, and particularly of different widths on

the minor axis; for instance, he might start with a circle 3 inches in diameter and then draw an ellipse 3 in. × 2½ in. and another 3 in. × 2 in., thus decreasing the length of the minor axis and maintaining the same length of major axis until this diminishing circle reaches the limit in a straight line. Having done this, he should draw inside of his circle some polygon, as shown in Fig. 18 (*a*), either an octagon or a hexagon, or even a triangle, and then project horizontally across from the circle, through all the ellipses, lines marking the corners of the polygon where they intersect the circumference of the circle. Short straight lines, connecting successively these points in the circumferences of the ellipses, will give a perspective view of the polygon inscribed in the circle, as shown at (*b*), (*c*), etc.

Fig. 5 of the drawing plate is a perspective view of a cylinder and a cone, the former standing on its base and the latter lying on its side. The top of the cylinder is an ellipse 2½ in. × ¾ in., and the bottom is a semiellipse of the same size. The height of the cylinder is 2½ inches, and straight lines connecting the extreme outside points of the ellipse and the semiellipse complete the drawing of the cylinder and represent it as it would appear in perspective. To draw the perspective view of the cone, a straight line is drawn from a point 1 inch below the right-hand end, the longitudinal axis of the ellipse forming the top of the cylinder, to a point ½ inch below and ¾ inch to the left of the right-hand end of the axis of the ellipse forming the bottom of the cylinder. On this line an ellipse 2½ inches long by ¾ inch wide is then drawn, similar to the ellipse forming the top of the cylinder. From the center of this ellipse draw a line 2 inches long perpendicular to its major axis, and consider this line as the axis of the cone. From the right-hand end of this line draw two lines tangent to the curve of the last ellipse, as shown, these lines forming the sides of the cone. This will complete the view of the cylinder and cone in perspective, and the portion of the cylinder that extends behind the cone, which is shown dotted in the drawing, should then be erased.

Fig. 6 represents an octagonal pyramid. The base of the pyramid shows an octagon in perspective, which is drawn within an ellipse $2\frac{1}{4}$ inches high by $\frac{3}{4}$ inch wide. Perpendicular to the major axis of this ellipse a line is drawn 2 inches long, which is the axis of the pyramid, and from the right-hand end of this line, straight lines are drawn connecting the corners of the octagon with the apex of the pyramid, thus representing that figure in perspective.

Fig. 7 is a perspective view of an ordinary tumbler, which, though slightly more complicated, and thereby demanding greater care in execution, is no more difficult to draw than either of the previous figures. The top of the tumbler is an ellipse $2\frac{3}{4}$ inches long by $\frac{5}{8}$ inch wide, and the bottom is one-half of a regular 30-sided polygon drawn within an ellipse 2 inches long by $\frac{1}{2}$ inch wide. The distance between the major axes of the two ellipses is 3 inches, and the sides of the tumbler are drawn tangent to the extreme ends of the curves. Above the bottom of the tumbler $1\frac{1}{4}$ inches, a third ellipse is drawn lightly, to indicate the point where the fluting starts. Within the two lower ellipses two semipolygons are drawn in perspective, each with fifteen sides. These semipolygons should first be laid out in a semicircle above and below the major axes of the two lower ellipses, as shown in Fig. 19, and the points of intersection of their sides with the semicircle projected to the ellipses of the tumbler, in order to locate the points to draw the polygon in perspective. It will be observed that this figure is simply a combination of the essential points of the two previous problems.

Fig. 8 is a vase, the outline of which is precisely the same as Fig. 21 of the previous plate, except that this view represents the vase in perspective, while the one on the previous plate was simply its outline in elevation. Where straight horizontal lines mark the details of the previous sketch, ellipses now show those parts in perspective. The ellipse forming the top of the vase is a very thin one, and the student should exercise care to insure the evenness of its curve. Draw all the parts lightly in pencil; make the curves

as perfect as possible, in order that the inking process may be carried out neatly and without any irregular breaks.

The last figure on this plate (Fig. 9) is another vase with which is combined the border drawn in Fig. 8 of the previous plate. The height of the vase from the center of the ellipse *a* forming its top to the center of the ellipse *b* forming its base, is 4 inches, and the longitudinal axes of these two ellipses are 1¾ inches and 1⅝ inches, respectively. The length of the neck from the center of the ellipse *a* to the center of the ellipse *c* is 1 inch, and from *a* to the bottom of the bulb *d* is 3¾ inches. The diameter of the smallest part of the neck is ¼ inch, and the lines gradually curve out toward *c*, where the diameter is ¾ inch. The border around the thickest part of the vase (which is 2½ inches in diameter) is ⅝ inch wide, and the line that forms the axis of the upper ellipse of this border, is 1⅜ inches below *a*. It will be necessary to divide the band within which the border is drawn into 4 equal parts, horizontally, as the straight band was divided in Fig. 13 of the previous plate. Then above the vase a semicircle must be drawn and divided into 24 equal parts, as shown for the tumbler in Fig. 19. Vertical lines drawn from the semicircle across the border band will locate points for the vertical lines in the fret border, and the horizontal lines may then be drawn, connecting them as was done with Fig. 8 of the previous plate; but the horizontal lines in this case will each be part of an ellipse parallel to the top and bottom elliptical lines forming the band around the vase. The vertical lines of the border will curve slightly as they approach the sides of the vase until the extreme outside lines on the right and left, will be practically parallel to the outline of the vase at those points.

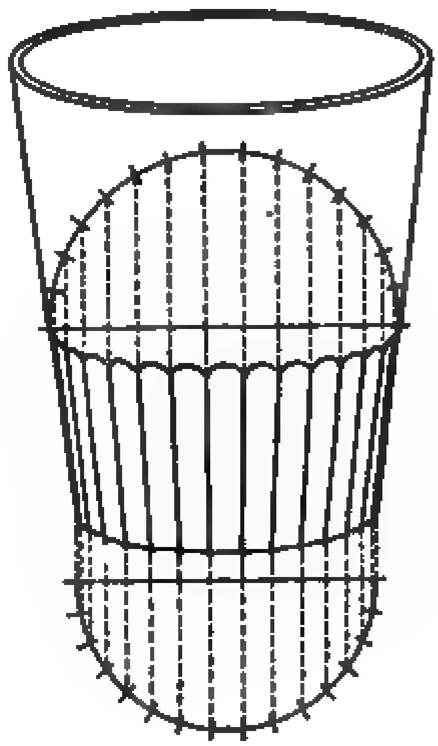


Fig. 19.

11. All the figures on this plate should be practiced on other sheets of paper until the student is satisfied that he can draw each of them evenly and neatly on his drawing plate. The oftener he practices the figures in this preliminary work, the easier he will find the subsequent problems. A few extra hours of labor expended in this part of the course will save much time toward the end. When the plate is completed in pencil, the student will draw the border line with his ruling pen and T square, as shown, print in the title in letters $\frac{5}{16}$ inch high, and ink in all the figures freehand. The construction lines may then all be erased, leaving nothing but the full lines of the drawings. The name, date, and class letter and number can then be neatly printed in their customary places.

DRAWING PLATE, TITLE: NATURAL LEAVES.

12. It is assumed that by this time the student is thoroughly familiar with the use of his drawing instruments, both mechanical and freehand, and in the following plates he will not be called upon to ink in his drawings with the freehand pen except in special cases. He should keep practicing the making of freehand sketches with the pen, however, in order that he may not lose the dexterity he has already acquired.

This plate consists of 12 figures, each representing some form of a natural leaf, and is intended not only to familiarize the student with the characteristics of each kind of leaf represented, but also to accustom him to the study of the botanical and geometrical details of all vegetable forms used in design. Nearly all leaves and flowers are governed in outline by some geometrical figure, and by varying this outline slightly, various leaf forms are made different, while the leaves are at the same time governed by the same geometrical figure. Draw a horizontal line through the plate 5 inches below the upper border line, and divide the space between this line and the border line into six rectangles;

NATURAL

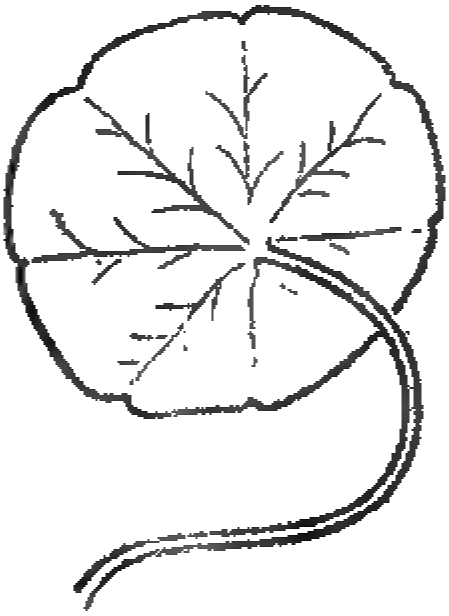


Fig. 1.

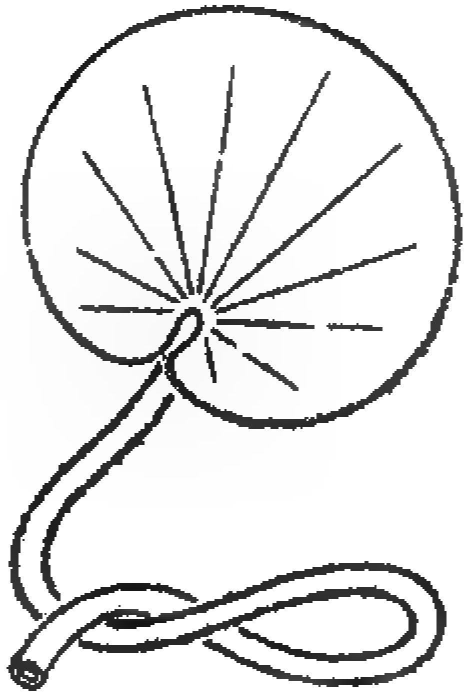


Fig. 2.

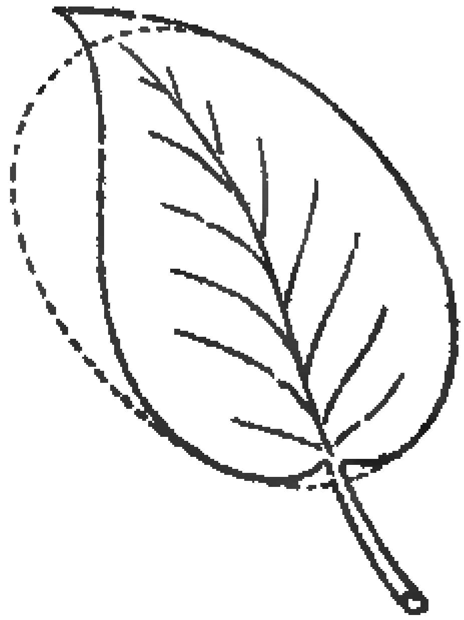


Fig. 3.

Fig.

Fig. 7.

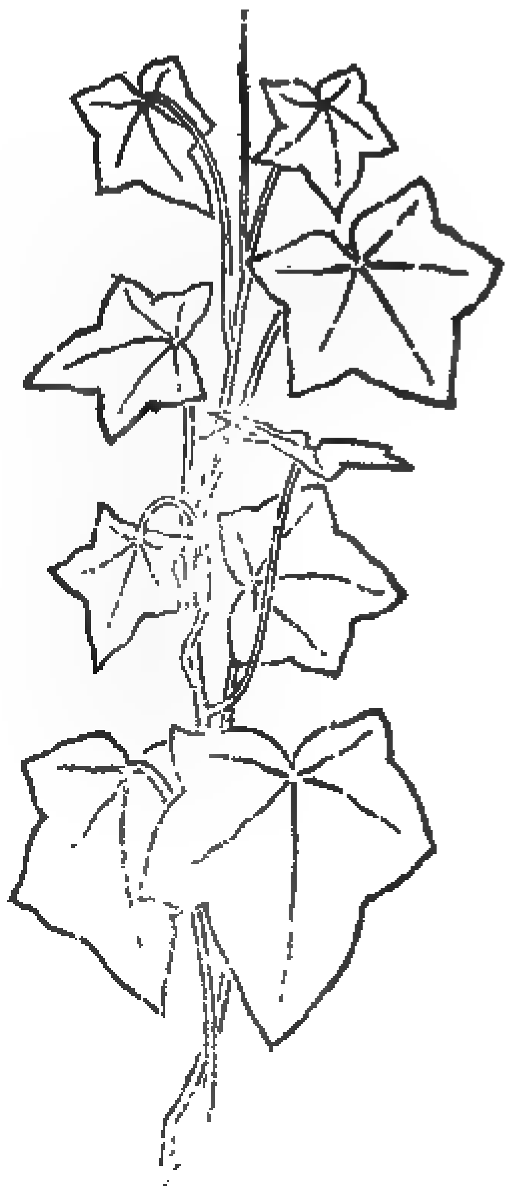


Fig. 8.

Fig 9.

LEAVES.

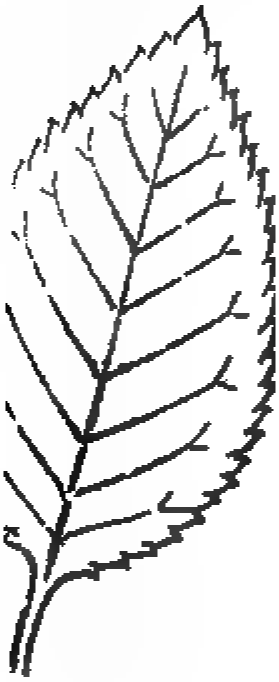


Fig. 4.

Fig. 10. Fig 11. Fig 12.

the ones containing Figs. 1, 2, and 3 will measure $2\frac{5}{8}$ inches in width each, and the ones containing Figs. 4 and 5 will measure $2\frac{1}{8}$ inches and $2\frac{3}{4}$ inches, respectively.

Fig. 1 is the leaf of the nasturtium, the governing outline of which is a circle, and the student should first draw lightly a circle about $2\frac{1}{2}$ inches in diameter, the exact dimensions being of no great importance. It will be observed that there are seven sides or lobes to the leaf, the lower one of which is the largest, and the others unequal. These lobes are expressed by making slight notches in the circumference

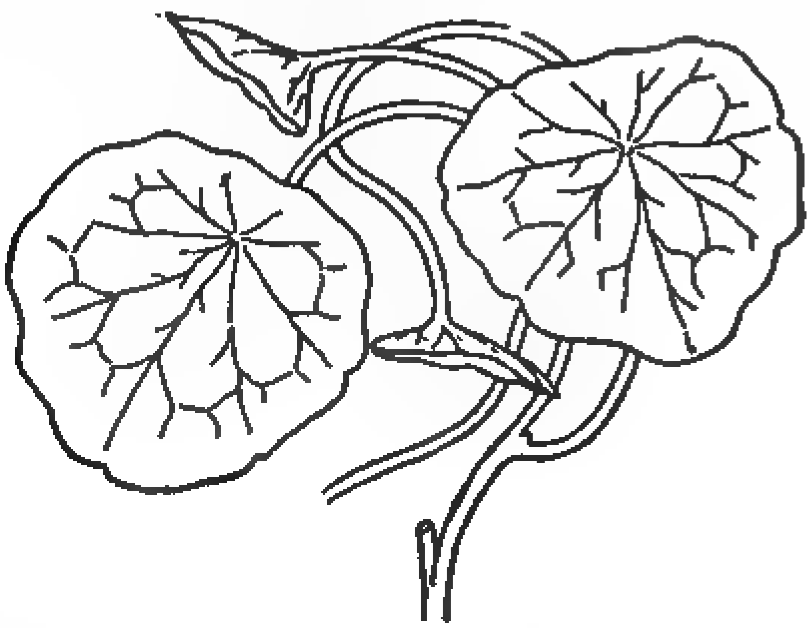


FIG. 20.

of the circle and then rounding them off into the main curve. The stem joins the leaf not on the edge but at a point about one-third the way up, and from it radiate seven veins, each toward one of the notches in the circumference of the leaf. It will now be observed that two of these veins form an almost straight line across the lower portion of the leaf, above which three of the veins radiate at almost equal angles. These are geometrical characteristics of the nasturtium leaf, and if followed out will enable the student at all times to present a fair portrayal of this class of vegetation. When used for embroidery work and other classes of design wherein a softness of outline is more consistent with the character of the material, the leaf may be expressed more freely, as shown in Fig. 20. In drawing this and the subsequent

figures on this plate, it is not desired that the student shall actually copy the drawing plate. His work will not be judged according to his accuracy compared with the copy, but according to the clearness with which he represents the object portrayed. It would be better for him, if possible, to procure a nasturtium leaf from the plant and make a drawing of that, using the characteristics in this description as a guide in the procedure. As said in the early part of this Paper, "A drawing is the expression of an idea by means of a picture," and the student's work on these plant-forms will be judged by the clearness with which he expresses his idea rather than by the accuracy with which he copies the figure.

The second figure on this plate is a leaf of the pond lily, also based on the principle of the circle, but with an even circumference that is deeply indented at the bottom. At the point of indentation a long stem joins the leaf, from which thin veins radiate toward the circumference. The length of the stem is a matter of little importance, as in nature it is governed by the depth of the water in which the lily is growing. The leaf in size may be the same or slightly larger than the nasturtium leaf, and the stem may be curled as shown on the drawing, or, if the student works from the actual lily leaf, instead of this copy, the stem may be drawn as he sees it in his original.

The leaves shown in Figs. 3 and 4 are characteristic of a number of plants, and vary in size with each plant. Their governing outline is practically an ellipse, as shown by the dotted lines. The student will draw for them two ellipses about 3 inches in length by 2 inches in width, as shown by the dotted lines, and then draw one side of Fig. 3, corresponding closely to the circumference of the ellipse. The other side diverges from the ellipse as shown, the leaf being pointed at its upper end and slightly indented at the bottom. A long vein extends from the stem of the leaf, which joins it at the bottom indentation, almost to the point at the top, and the side veins branch to the right and left. After the drawing is completed, the construction lines may be erased.

The drawing of Fig. 4 is precisely the same as Fig. 3, except the edges of the leaf are serrated or notched, as shown, and there is no indentation at the bottom, the leaf ending in a point at that end also, but more abruptly than at the top. This is the style of leaf characteristic of the rose and of the elm tree, though on the former plant it forms one of a group of leaflets, and is seldom more than half this size.

The spray of leaves in Fig. 5 is from the maple tree, and their governing outline is a pentagon, not a regular pentagon with equal sides, but one whose base is considerably longer than the other four sides. The indentations in the top lobe are more marked than those in the side lobe, and vary in different leaves. In fact, no two leaves are ever exactly alike, though the characteristics are always the same, and there should be no difficulty in portraying a maple leaf so that it is unmistakable for this class of vegetation. The lower lobes of the leaf are sometimes rounded, and in the younger leaves the indentations are much less marked than in the mature ones. In drawing the spray shown in Fig. 5, draw the large leaf first, and fit the smaller ones in under it, as shown, not necessarily following this exact arrangement, but placed in such a manner that they will show the characteristics of the leaf. Maple leaves are easily obtained in nearly all communities, and the student should certainly draw this figure from nature, if possible. The maple leaf can be characteristically and conventionally designed within the sides of a regular pentagon, however, as shown in Fig. 21.

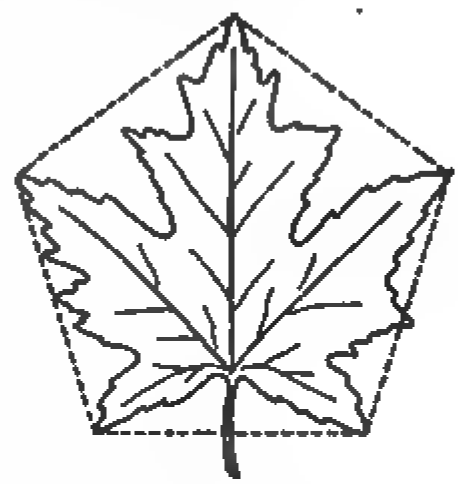


FIG. 21.

Fig. 6 is a cluster of one class of horse-chestnut leaves, the governing outline of which is practically a hexagon. Each leaf is complete in itself, but as they always grow in a cluster at the end of a stem, with almost invariably the same number in a bunch, it is proper that they should be so represented,

especially in design, as this is one of the geometrical characteristics of their botany. The true horse-chestnut leaf has invariably seven leaves in a cluster, arranged in the same manner as this example, but there is another variety of the same tree that has either five or seven in a cluster. To draw Fig. 6, first construct a general outline of the group as explained in Fig. 1, and then draw in the individual leaflets. The general outline will be somewhat the shape of a hexagon, with the outside points of the leaves and extremity of the stem in each of its angles. In drawing the leaves, observe that they are larger at their outer ends than toward the stem; that the notches in their edges extend into the leaf toward the stem, and are not sharp, straight lines, but curved in the same direction as the veins of the leaf. The last point at the extreme end of the leaf is considerably longer than the others, and tends to give a spear-like termination. The peculiar form of the leaves permits them to cluster nicely in a bunch, as shown, and enables them to be conventionalized and easily used in certain forms of geometrical designs.

These six figures, constituting the upper half of the plate, will servé to familiarize the student as far as is necessary with the geometrical and botanical characteristics of these particular forms. He should make it a point, however, to study other forms, and broaden his knowledge as much as possible in the observation of nature. He should frequently draw the leaves of different plants, and if his drawing does not convey a satisfactory idea of the leaf itself, he should analyze his drawing carefully, and also the natural leaf, and learn wherein he has altered or omitted some detail that stamps the character of the original. These leaves have been drawn singly because they are usually seen singly on the trees, or on the ground under the trees, with the exception of the horse-chestnut leaf; they are seldom associated in the mind as clusters. In the next six figures, however, a class of leaves is considered that are associated with the vine or plant on which they grow, and their characteristics must be considered. not singly, but together with the plant and

surrounding details. Figs. 1 to 6 represent, also, a development in botanical evolution, the theory being that the fundamental leaf form was circular, as in Fig. 2. The notches in the outline of Fig. 1 are indicative of a lack of nourishment being conveyed to the margin of the leaf at certain points, thereby retarding its growth; the serrations in the edges of Fig. 4 are caused by a similar lack of circulation of sap, until finally we come to Fig. 5, where the serrations are so developed as to make lobes on the edges of the leaf, and in Fig. 6 to cause the leaves to grow in clusters at the end of one stem, instead of a single leaf. The different forms of the edges of leaves so developed are due to the system of veining. A study in comparison of different forms of leaves will soon place the student in a position to judge and recognize the proper veining of a great many leaves, according to the indentation of their edges. The nasturtium leaf is indented regularly at the end of each vein, and the veins are regular and straight. In the maple leaf the indentations are very irregular, because the veining of the leaf is irregular and forms a network throughout the whole tissue. In the horse-chestnut leaf the general veining is regular in each individual cluster, thereby causing an even subdivision into a uniform set of individual leaflets, while the edges of each leaflet are serrated, owing to a slight irregularity in their individual veining.

Fig. 7 is a spray of the vine and leaves of the convolvulus, which is of the class of vine to which the morning glory belongs, and the student will not attempt to draw the same until he has, on a separate piece of paper, frequently practiced the drawing of the individual leaves of the plant. The number of leaves on the stem will depend on the object from which he draws. If he can secure a slip of the vine itself, he will draw it as he sees it, locating the leaves as he sees them, and not in any way attempting to copy his drawing plate, but referring to same for the expression of the stronger characteristics of the growth. If he cannot secure a slip of the plant, he will have to make his drawing from the plate. The leaves of this example are triangular, slightly

indented at the bottom, and manifest a strong inclination to curl up slightly at the edges. They are a soft leaf, and rarely lie stiff and flat, like the maple. In drawing them, the student will observe the character of the veining, the arrangement on each side of the main stem, noting that they branch alternately, and that no two of them start from the same point. The leaf that is turned over, showing its under side, indicates the method and manner of the stem joining the surface, and in making the drawing the student has but to bear in mind that the governing principle is an isosceles triangle, as shown in Fig. 22, and the arrangement on the stem is an alternation on opposite sides.

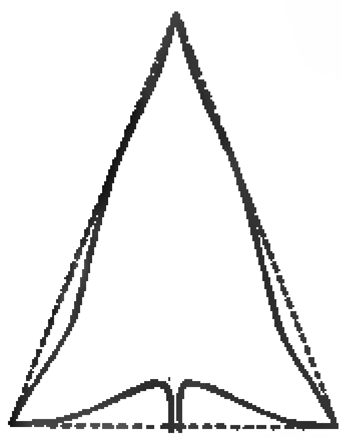


FIG. 22.

Fig. 8 is a spray of ivy leaves, each of which may be drawn within a pentagon, as shown in Fig. 23, in the same manner as was described for the maple leaf. The edges of the ivy leaf are not serrated, and the sides of each lobe are distinctly curved. Each leaf has five lobes; the stems join them in a stiff, angular way at the lower indentation, and are heavy in proportion to the size of the leaf. The leaves do not show the wavy outline of the morning glory, for they are naturally stiff and somewhat clumsy. The stem from which the leaves branch is of a woody texture, and is much stiffer and harder than the stem of the morning glory; therefore, it does not grow in a wavy line, and care should be taken that, though the ivy is a vine and manifests as strong an inclination to climb as does the morning glory, it does so in a stiffer and more regular manner—a characteristic that should always be expressed when it is used in

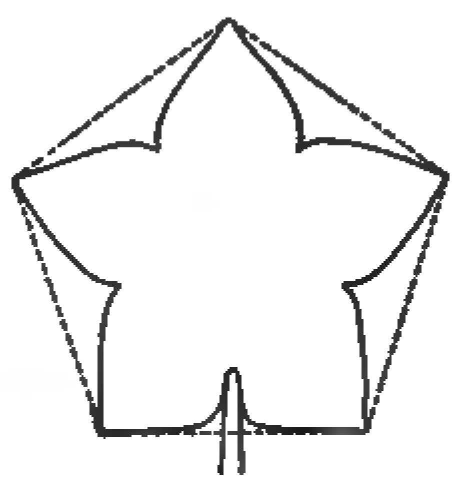


FIG. 23.

design. The student will draw Fig. 8 as shown, or from the natural leaves, if such are obtainable.

Fig. 9 shows the long stem of the lily. There are several classes of lilies that manifest different characteristics in some of their details. This view shows the principle on which the leaves branch from the stiff stem, their tendency being to grow upwards toward the flowers, which bloom at the top. Each individual leaf is a plain straight blade, sometimes with a strongly marked central vein, and at other times with a number of veins running through it. Its lower end wraps itself partly around the stem, and in some classes, such as the tiger lily, the flowers blossom at the juncture of the leaf and the stem, and after the flowers have blossomed, a round seed marks the place where they stood on the stem.

Fig. 10 is a branch of the olive tree—a very difficult specimen to get from which to draw from nature, but an important leaf in design, as it has always been held as the emblem of peace. The leaf of the olive is long and narrow, very slightly widened at its upper end, somewhat after the general shape of the chestnut, but softer and not so conspicuously unequal. The fruit grows on branches under the leaves, with six or eight olives on each branch. In drawing this little spray, it is simply necessary to indicate the main branch about as shown on the plate, and draw the two leaves that terminate at its upper end. The next two leaves below these grow out of opposite sides of the main stem, from the same point in height. They are not directly over the ones below or under the ones above, but take a position half way around the stem from these, so that if the stem were so held that any two of its leaves pointed toward the north and south, the pair next above and below them would point toward the east and west. This is a characteristic that should always be borne in mind in representing the plant.

Fig. 11 is a branch of laurel introduced here with the olive on account of its symbolism, the laurel wreath being an emblem of victory. The shape of the laurel leaf is not

widely different from the olive, but it is much larger, being 3 inches or more in length, while the olive is seldom more than 1½ inches or 2 inches. The leaves of the laurel grow all around the stem, branching alternately from opposite sides, and the edges, though not serrated like the rose leaf, are indented by a series of rounded notches at the end of each vein. The flowers of the laurel blossom in the angle between the leaf and the stem.

The last figure on this plate (Fig. 12) shows two kinds of the palm—a plant emblematic of royalty. The palm leaf is used largely by the Egyptians in many of their designs, and from it were made several devices and utensils important in the ceremonies and customs of the complicated formalities of the ancient Egyptian society. In drawing the palm as shown on the plate, the student will observe that in one example of it the leaf radiates from the end of the stem, and he must bear in mind that though the edge is ragged and broken up into a number of string-like terminations, its natural unbroken form is practically circular, and that the delicacy of the tissue composing the leaves causes them to be shredded on the edges when blown together in high winds or handled roughly when taken from the tree. This variety is known as the *fan palm*. The other form of palm, called the *feather palm*, is similar in texture of leaf to the first, but its veins radiate from a line instead of from a point; this difference of radiation will recall to the student Figs. 18, 19, and 20 of his first freehand drawing plate.

The student will complete this plate and draw the border line, but ink in none of the figures. It is desired that he should become accustomed to drawing rapidly and readily with the pencil and expressing himself with as few lines as possible. He must bear in mind that he is not to be a copyist, that no two leaves in nature are alike, and, therefore, it is unnecessary that he should portray any of the leaves on this drawing plate exactly like the example we send him. However, he must remember that in each case he is solving a problem; he is endeavoring to express by means of a picture the idea of a certain form of leaf, and that failure to

express all the characteristics of that particular leaf makes the solution of this problem incorrect. The title may be put on the top of the plate, as shown, and the name, date, and class letter and number printed below the margin line as heretofore.

DRAWING PLATE, TITLE: FLOWERS AND CONVENTIONALIZED LEAVES.

13. On this drawing plate the student is given a few examples of familiar flowers, and the same remarks concerning the method of drawing them applies here as with the previous plate. Original flowers are to be preferred rather than printed copies, and whenever such are obtainable, the student should avail himself of the opportunity to draw them.

In Fig. 1 is shown the morning glory, its bud, and the method of its branching from the vine. The flower itself is trumpet-shaped, the upper end being practically circular, which makes it elliptical when shown in perspective, as it is here. The sides of the tube forming the lower part of the flower are curved slightly, and gradually approach a straight line toward the stem. Observe that where they join, the little leaves around the bottom of the tube have pointed ends and form a cup called the *calyx*, in which the trumpet-like flower sets. Observe that the bud of the flower is twisted, producing a screw-like effect, as shown to the right of the open blossom.

Before drawing this plate, divide the paper lengthwise through the center, 6$\frac{5}{8}$ inches above the lower border line, and above this center line construct five rectangles 3$\frac{1}{4}$ inches in width and 5 inches high, with the center line as their common base. Proceed to draw Fig. 1 in the first rectangle by constructing an ellipse about 3 inches above the center line of the plate and about 2$\frac{1}{4}$ inches in length on its major axis, and $\frac{1}{2}$ inch or a little more on its minor axis. Within this ellipse, describe the slightly scalloped edge of the upper portion of the blossom. Draw the lines

forming the trumpet-like tube of the lower portion of the blossom, and then draw the stem. The main stem of the vine runs from the lower right-hand to the upper left-hand corner, and by noting where it crosses the upper edge of the blossom, its position on the plate can be determined with sufficient accuracy. The leaves and bud may then be drawn in their relative positions.

If the flower is drawn from nature, as heretofore suggested, the student need not follow closely these directions, except so far as they apply to inserting each problem in its proper rectangle.

Fig. 2 shows two flowers somewhat alike in their general formation but possessing characteristics that stamp them so forcibly that it is impossible to mistake one for the other; these are the phlox and the carnation. Both flowers possess five petals radiating from the center. The petals are larger at their outer ends and taper almost to a point where they come together. They enter the top of an almost straight tube that is held at the bottom by the little green calyx, where it joins them to the stem. This tube, however, is larger in the carnation than in the phlox, and the carnation itself is a larger flower than the phlox. The edges of the petals of the carnation are toothed very sharply and very plainly, while the edges of the phlox are round. The outline of the ends of the flowers are practically governed by a pentagon, and in drawing them the student should be careful to emphasize the characteristics of each, the strongest distinctive characteristics being the round petal of the phlox and the toothed petal of the carnation.

In making the final drawing of these flowers on the plate, the student will locate the first carnation of the bunch in the upper left-hand corner of the second square, as shown. He will then draw it so that its stem will pass out of the square near the lower right-hand corner, and then successively draw the other two blossoms in place, to the right and left of the first one. The outline governing the ends of these blossoms is practically elliptical, although the edges of the petals vary more in the carnation than they did in the morning glory.

In drawing the phlox, observe that the petals of the flower form a part of the tube that connects the flower with the stem, thus differing from the carnation, where the petals grow out of the tube. The outlining of the petals is practically the same, though on a smaller scale, and the governing outline of the top of the flower is an ellipse, as in the previous cases. Observe here that the blossoms of the phlox are all on one stem, while with the carnation each separate stem carries a flower.

The exact arrangement of these flowers on the plate is not of importance as long as they are within the second square.

In Fig. 3 is shown a couple of sprays of a little flower known as the harebell. The flowers themselves are cup-shaped and hang from fine thread-like stems that grow alternately on opposite sides of the main stem. It has no large leaf like most flowers, but a series of little spur-like projections along the stem, as shown. The edges of the flower are indented by fine notches that curve in from the top, and the spaces between these indentations rise to little sharp points, giving the flower a very pretty and strongly characterized marking. The bud, as shown at the top of one of the sprays, is formed by the ends of the flowers closing over and folding themselves within, and does not twist around like the buds of the morning glory. In drawing the figure, try to keep the flowers in a graceful position; also prevent any appearance of stiffness or forced regularity, and especially be careful to draw them with a light delicate touch, avoiding a crude hard line, as one of the strongest characteristics of the flower is its delicacy, and this would be destroyed by too harsh a rendering of the pencil.

Fig. 4 shows the ordinary dogrose, the flower possessing five petals, which radiate from the center and are slightly curled up on their outer edges. Where they join, a series of fine hair-like filaments (botanically known as pistils) mark the center. The leaflets grow on opposite sides of a thin stem, usually three on each side and one on the end, and the edges of the leaves are sharply serrated, as explained on the previous plate. The thorn is characteristic of all kinds of roses, and should always be expressed as a characteristic of the plant.

Fig. 5 is the common field daisy—a flower easily obtainable during the month of June, and a very interesting subject for various classes of design. It grows at the end of a long stem, at the lower part of which the ragged leaves branch and spread on the ground. The flower itself varies in size from 1 inch to 1½ inches in diameter, is practically circular in outline, and consists of a number of white petals that branch from a central disk or sun in the center, about one-fourth the diameter of the whole flower. The petals vary in number, and branch out thickly on all sides, forming a solid white disk. The side view of the daisy shown on this plate illustrates the tendency of the leaves to grow upwards slightly, and also shows the thickness of the sun or center piece below the petals of the flower. In drawing the daisy, it is well to sketch in the outline as a circle, and to draw the sun as a circle, and then, one at a time, indicate the petals or rays that branch around the edge. The petals are rather wider at their outer end than in the middle, and taper almost to a point where they sprout from the flower; two deep notches in the end cause three teeth to be characteristic of their outer extremities.

Now, besides drawing these five examples of wild flowers as shown on this plate, the student should take every opportunity to study the flowers themselves, and after he has drawn the details of each flower as he sees it in blossom, it should be taken apart and analyzed. For example, we take the wild rose and pull it apart, and make an individual drawing of one of the petals, or of all of them, as shown in Fig. 24. Every detail of every part of the plant should be similarly drawn, in order that we may become familiar with the characteristics of the plant as separate from the plant itself. The leaves in their arrangement on the stem should be made

FIG. 24.

the subject of another drawing, and this drawing of the details of the flower preserved as a guide to be used when the flower itself is expressed in a conventionalized design. The practice of thus drawing the details of a flower, or other vegetable form, is called *plant analysis*, and is the only way by which the strongest characteristics of every individual plant can be properly studied.

In drawing the figures on the upper half of this plate always outline the grouping first, as explained heretofore. Then draw the individual outline governing the extremities of the flowers, etc., and finally fill in and develop the detail.

The lower part of this plate contains four figures, and requires that the plate, below the center line, should be subdivided as follows: The center line of Fig. 6 is 2⅜ inches to the right of the border line, and its top is tangent to the horizontal center line of the plate. The center line of Fig. 8 is 8¾ inches to the right of the border line, and the rectangle containing Fig. 8 is 3 inches wide by 6 inches high. Fig. 7 is then fitted in between this rectangle and Fig. 6. The wall on which the bracket in Fig. 9 hangs is about ¼ inch to the right of Fig. 8. By locating these points on the plate the student will have no trouble in drawing his figures in the proper places.

With Fig. 6 of this plate we take up the first part of the subject of conventionalized forms. It is seldom that a plant or other form from nature can be used in a design with reason without reducing it to a plain practical form that is conventional or symbolic more than pictorial. Fig. 6 is a conventionalized form of the acanthus leaf, and as we draw it we will endeavor to get a better idea of the meaning of the word *conventional*. In the first place, the outline of this figure is based on the ellipse, and the student's first move will be to construct in the corner rectangle of his drawing plate a semiellipse 4½ inches high and 4 inches wide. Within this he will draw the main outline of the lobes of the leaf, as shown in Fig. 25, observing that these lobes are farther apart as he approaches the top of the leaf, or, in other words, are closer together at the wider portions of the

leaf. There is a central lobe and three smaller ones on each side. The top lines of the side lobes are curved, but are nearly horizontal in position, and the side lines of the lobe are inclined slightly toward the center of the leaf. The middle vein is a straight line on the major axis of the ellipse, and the side veins curve from the points of the lobe to the bottom line, as shown, and approach the central vein as they reach the bottom; in other words, if all the veins of the leaf were continued downwards, they would eventually meet in a point like the lines radiating from a point in Fig. 18 of Drawing Plate, title, Linear Elements. The acanthus leaf is now drawn by serrating the edges of these lobes, following the drawing plate as closely as possible. The inner angles of the lobe are then carried into the leaf in the form of loops, the vertical lines usually being the ones that govern the direction of the loop. The leaf lobes are then drawn as though lapping over one another slightly, and extra lines are drawn indicating the sides of the *pipes* or tubes that are naturally formed in the leaf where these loops exist. This can be more readily understood by referring to Fig. 39, where the surface of the conventionalized leaf is shown as it usually appears when carved in stone or wood or modeled in clay or plaster. It will be seen that the sides of the leaf on this plate are symmetrical, that the leaf is perfectly flat in the drawing, and no attempt is made to shade it. The existence of the last line drawn from the loops down is indicative of the raised surface of the pipes on the leaf. This is the expression of an idea by means of a picture. It is not a picture of the acanthus leaf as it appears in nature, but a

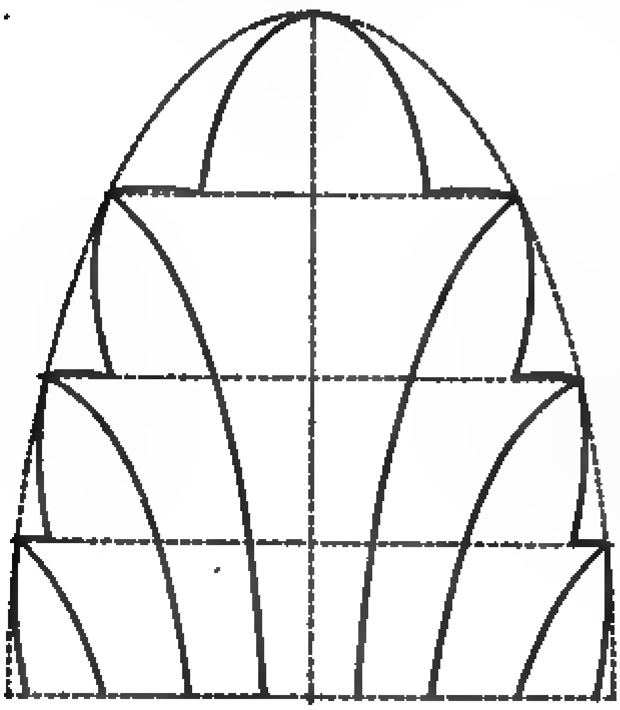


FIG. 38.

picture of the characteristics of the leaf—characteristics that are themselves emphasized beyond the mere drawing of the leaf itself, and it is the emphasis of these characteristics that distinguish in the drawing of a leaf or flower the naturalistic and the conventional rendering. Flowers and leaves may be rendered naturalistically if they are painted on canvas or printed on paper, but if woven in cloth or carpet, or used as a part of a wall-paper design, or burned in leather, the details of the process by which they are thus reproduced will not permit of an accurate portrayal of them naturalistically. They are therefore conventionalized, and lines indicating their strongest characteristics are woven, printed, or carved to stamp the leaf for what it is. In drawing this figure, complete both sides. The example on the drawing plate was left unfinished on the right side in order to show the relation of the semiellipse.

Fig. 7 is a side view of the conventionalized acanthus as it is sometimes used in connection with scrollwork on brackets. The S-like outline of the leaf is first drawn about 4½ inches high; the lower curve is then drawn to measure 2½ inches across, and the upper curve about ¾ inch across. The lobes are then outlined exactly in the same manner as the previous case, and the indentations drawn within these outlines, as before. The veins running from the center of the lobes are then drawn, following the contour of the lobe itself, and finally becoming tangent to the main curve at the outside of the leaf. After the leaf has been drawn, the guide lines, which are shown dotted on the original drawing plate, may be erased by the student, and the drawing of the leaf itself completed.

In Fig. 8 is shown a panel in which is drawn a conventionalized design based on the growth of the ivy, and which is, with slight alterations, a suitable design for carved wood or burnt-leather work, or even for embroidery. The details are not as conventionally rendered as would be necessary for certain woven work, such as damask linen, or silk, but the two sides of the design are precisely alike, and the details all geometrically arranged so as to reduce the whole to a

mathematical principle. In drawing the panel, make its dimensions 3 inches wide by 6 inches high, and divide it into eight equal rectangles each 1½ inches square, as shown in Fig. 26. Within these rectangles then draw a number of pentagons, more or less irregular, according to the outlines of the various leaves, and generally indicate the lines of the main stem of the vine where it crosses the dividing lines of the squares. Notice that the center of the main stem crosses the center line of the panel *a b* about one-fourth of a square above the bottom, and it curves so as to cross the horizontal line *c d* a little less than one-half a square each side of the center line. The two stems then cross each other on the center line one-third of a square above the horizontal line *c d*, and they cross the horizontal line *e f* about one-half a square to the right and left of the center line. These stems then cross the line *g h* about one-third of a square each side of the center line *a b*, and cross each other on the line *a b* one-fourth of a square below the horizontal line *g h*.

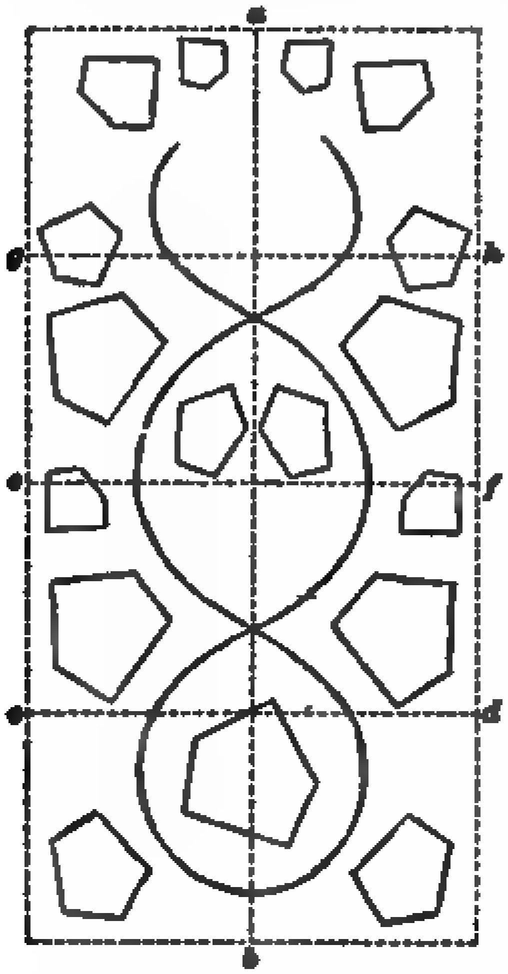


FIG. 26.

These measurements are not absolute and should be judged by the student entirely by the eye. A principle to be observed is that the arrangement of the panel is based on the same rules concerning foliated ornament that were given in connection with the Drawing Plate, title, Linear Elements, under Art. **9.** The strongest growth should be at the bottom, the arrangement of the leaves and area covered by them should diminish toward the top, and though it is not the nature of the ivy that its leaves should grow tangentially

from the stem, the stems should be so arranged that they appear to grow gracefully and rationally, one out of the other, without abruptness or severity. The main stem, however, should be stiff, rigid, and geometrical, as explained in the instructions for drawing the ivy leaf on the previous plate, as this stem is stiff and woody in its natural growth. Within the pentagons that have been previously drawn to indicate the locations of the leaves, carefully outline the five lobes of the ivy leaf and connect them with a gracefully curved stem with the main lines of the growth. Enclose the whole design in a border line, as shown.

In using such a design as this for practical work, the relative sizes of the stems and tendrils may be materially altered. Certain materials and methods of handling will permit a much more delicate treatment than is here shown, while other conditions will demand that all the lines be bolder and that some of the details at the top of the panel be suppressed entirely. For instance, if the design were to be embroidered, the colors to be used would determine largely the strength of the line of the stem, dark colors always looking heavier than light ones. The curve and arrangement of the fine tendrils at the top would also be altered, as the tracing of these lines would be governed by the possibilities of the handling of the thread employed. If the design were to be carved in wood, the tendrils at the top would probably be omitted entirely, and heavier forms replace the smaller leaves. The nature of woodwork would not permit so delicate a treatment at the top, and as the omission of the tendrils would leave a blank space that would look unfinished, the leaves themselves should be enlarged to satisfy the feeling that the proper area at the top had been covered. In the smaller stems, throughout the body of the panel, the design would probably require strengthening, that it might be better expressed in wood, and their increase would require a general increase in the thickness of the main stem throughout, in order that the proportions of one to another might remain the same. After the student has carefully outlined these details he should

strengthen up the general lines of his drawing, clean off his guide lines, and then finish the figure in pencil.

Fig. 9 is a bracket and hanging sign, similar in every respect concerning its general outline to the bracket and sign drawn by the student on Drawing Plate, title, Surfaces and Solids. The student will draw the outline of this bracket and sign precisely as before, but where the lines of ironwork split and branch into separate scrolls, he will cover the joint with a drawing of a conventionalized leaf, the details of which he has just studied. The length, size, and proportions of the different parts of the leaf he must judge by his eye, observing that the outline of the leaf follows

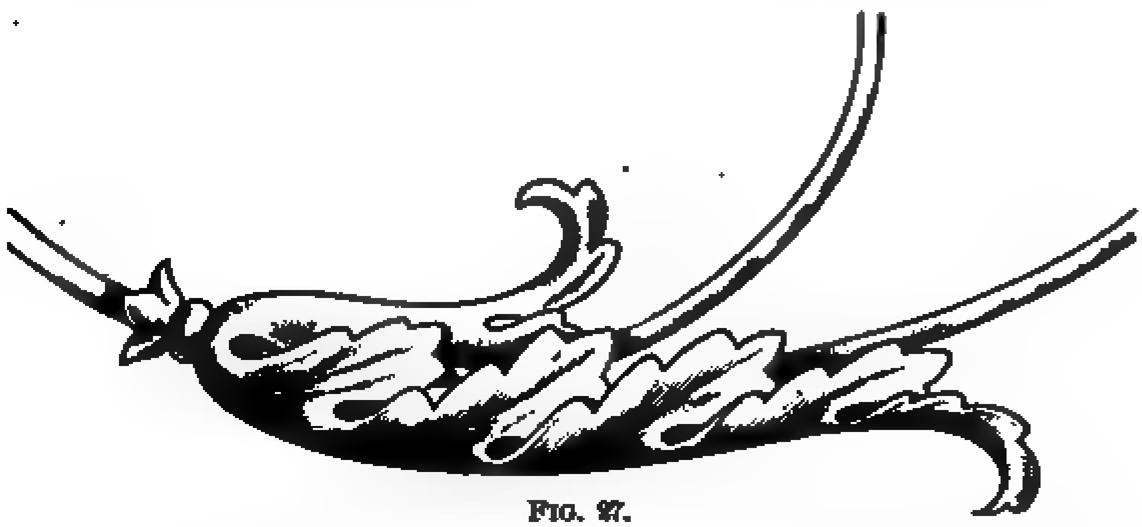


FIG. 27.

closely the outline of the ironwork that it covers, and observing, also, as he draws it, that he is converting a plain strap-iron bracket into an ornamental device, requiring in its execution the greatest skill in the ironworkers' art. It is also well for him to know that in the execution of a design of this character for an ironwork bracket that might be used either as a sign hanger, or as a design for a chandelier or gas bracket, he has to exercise the same judgment in the formation of the leaf as was necessary when he made his drawing of the cartouch on his second freehand drawing plate. The leaf itself must be cut out of plain sheet iron by the ironworker, and hammered into the shape expressed by the designer on his drawing. It is well, then, for the student to study what the developed shape of this leaf would be if it were flattened out. He will probably then find by

a

Fig. 1.

Fig. 2.

Fig. 3.

c

Fig. 6.

Fig. 7.

Fig. 9.

Fig

Fig.4.

Fig.13.

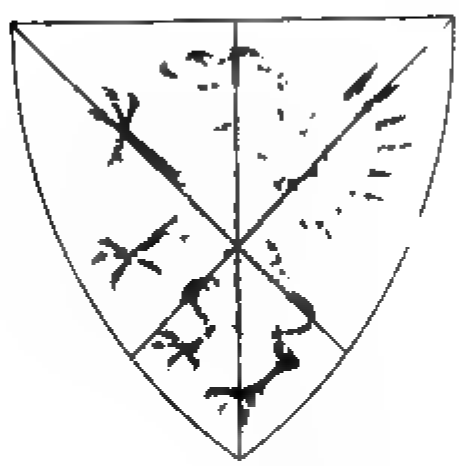


Fig.12.

Fig 14.

experiment that the leaf can be improved in design by varying some of its dimensions. Referring to Fig. 27, we see a piece of iron scroll projecting from a hammered ornamental iron leaf, while in Fig. 28 a developed form of this leaf is shown in outline before it is hammered into this shape. It is a simple matter, and a very instructive practice, for the student to experiment in drawing and making these devices of paper or thin metal, as was suggested previously in the drawing of the cartouch. Very thin brass or copper is an excellent material to practice with. It may be readily cut to any desired shape with ordinary scissors, and bent and creased with the fingers to bring it up to the finished shape, and the student that can both draw and model his designs will be in better shape to execute satisfactory compositions than the one that is simply satisfied to express his ideas on paper.

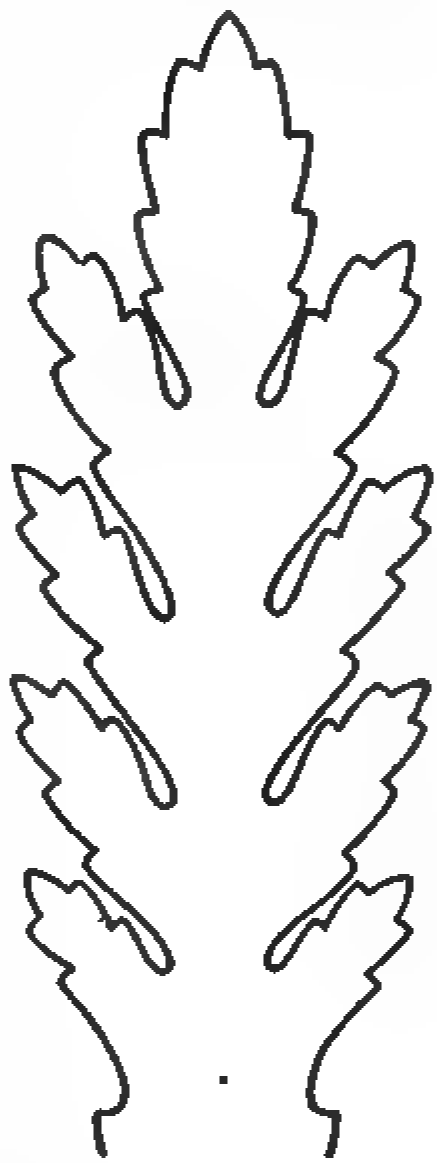


FIG. 28.

The student will finish drawing the bracket as shown on the drawing plate, and, after drawing the border and inserting in the title at the top, will letter his name, date, and class letter and number below the border line as heretofore. The figures on this plate will remain in pencil.

DRAWING PLATE, TITLE: BRUSH WORK.

14. As expressed in the first part of this course, design in its most elementary state consists of an arrangement of lines, these lines forming the boundaries of several shapes or definite forms; they may be straight or broken, heavy or

fine, firm or delicate. This variation of the quality of each line, combined with the possibilities of variation in arrangement, renders it possible, as already explained, to give a great variety of expression to a design that consists of lines only. Certain classes of work depend entirely on this line arrangement for their value as artistic productions. In dress goods, a great variety of plaids, though influenced by the combination and comparison of their colors, are dependent more largely for their beauty on the arrangement, weight, firmness, and delicacy of the lines of color that constitute their design. In leaded and stained glasswork the necessity of uniting the multitude of pieces with strips of H-shaped lead, compels the design to assume in its composition a number of irregular black lines that the skill of the designer arranges to form a part of his composition and therefore renders inconspicuous. The design of a window may consist of delicate figures and foliage, or it may be simply a heraldic or symbolic device, but the lines of the lead work must each be considered as a part of the composition; otherwise they will interfere with the repose of the whole and render it inartistic and unsatisfactory. In order to produce lines expressive of beauty, the hands must be well trained to execute the ideas of the mind, and the mind well trained in matters of art and composition. It is for the former of these requirements that the student has been drilled on these simple exercises of freehand drawing, but the latter can be acquired by him only through a persistent study and analysis of the works of art through all ages.

In the drawing of lines with a pen or pencil there are limits to the weight, strength, and firmness that can be expressed, but with the brush there are no such limitations, and by varying the size of the instrument, and the shade of the ink, or other medium used, there is no extreme that may not be reached in the matter of boldness, power, and nobility of expression in any design, whether it is composed of individual lines or of shaded surfaces. In drawing lines with a brush there are many kinds of instruments that will produce the required results, but the Japanese painting brush, shown

in Fig. 29, is undoubtedly the simplest, after the student has become accustomed to its management and the peculiar method of holding it.* The brush is not held as is an ordinary water-color paint brush, but is managed after the

FIG. 29.

Japanese method, and held as shown in Fig. 30, in order that there may be perfect freedom of movement to the hand and power to produce even results in all directions. To draw simple lines with the brush, the student should practice according to the following directions until he has acquired such dexterity in its management that he feels confident of properly executing the problems on the plate. If the student finds he can do better with an ordinary brush, there is no objection to his using it.

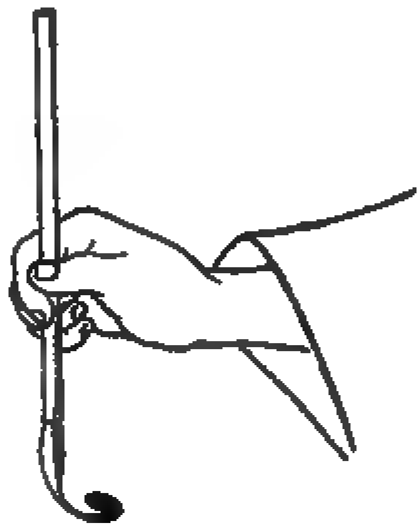


FIG. 30.

In the general practice with brush work the student should not use his ink in full strength; in fact, it is a great deal better that his wash drawings should be executed with a very dilute ink producing a gray wash, instead of a heavy black silhouette-like effect. For this purpose, Stafford's "*Not Waterproof*" or Higgins' "*General Drawing*" ink may be diluted with four to eight times its bulk of water, and used to produce a tint about the same as that shown on the accompanying plates. A good way to do is to pour a

*If the Japanese brush is not used, the student may practice with ordinary camel's-hair brushes, such as are used in general water-color work. These are held in much the same manner as a pencil, but the hand is not as free as with the Japanese brush. We, therefore, advise the student just beginning to study brush work, to use the style of brush illustrated in Fig. 29. All new brushes should be soaked in water one hour before they are used the first time, and washed clean and wiped after using. After wiping the brush, it should be moistened in the mouth and its hairs drawn to a point between the lips. It may then be put away and allowed to dry.

small quantity of ink (2 or 3 drops being usually sufficient) in a small saucer and add thereto enough water to reduce it to the desired color. This may be determined, after stirring the brush in it thoroughly, by drawing a light wash of it over a piece of paper and allowing it to dry. If the tint is lighter than that on the drawing plate, or is very much darker, then more ink or water must be added to change its tint to the one required. A very little practice will enable the student to judge the amount of dilution necessary. Drawing ink thus diluted is usually called "color"—a term used in brush work, generally, to indicate that there is a variation of tint rather than an even monotone.

It may also be pointed out that where a drawing is to be executed in ink and afterwards washed in, in color, as in the wash tint above described, that the outline of the figure should be drawn in *waterproof* drawing ink, and the wash work done with dilute general ink. The reasons for this should be apparent. If the outline is drawn in general drawing ink, which is not waterproof, the wet color will cause it to spread and become ragged on the edges and contaminate the tint and destroy the even effect of the outline. Whereas, if the outline is drawn in the waterproof ink, and then waterproof ink is diluted to use for the wash work, the ingredients added to the ink to make it waterproof are antagonistic to its dilution, and the wash of this ink is likely to settle in uneven spots and make an irregular and dirty-looking drawing.

15. Whenever a considerable surface is to be washed over with an even tint of color it is necessary that plenty of color be first taken in the brush, and the upper left-hand corner, or other convenient point of the subject, be lightly drawn in with the point of the brush, and the color then spread evenly and generously over the entire surface. The color can be carried to any extent by recharging the brush from time to time and adding it to the surface that is not yet dry, or to the bottom of the previously applied color, which should always be allowed to remain in a slight pool while the brush

is recharged. Should the color dry, or become nearly dry, it will be impossible to apply a new tint over it of greater extent, without showing a line where the first wash stopped. In applying color in this manner, the student should incline his board so that the color will flow downwards, and can be led in even advances by means of the brush; and each time the brush is recharged with color it should be stirred around in the saucer so as to evenly distribute the pigment, or coloring matter, through the fluid.

The student can readily learn the value of placing one tint over another by drawing in pencil a rectangle 8 inches square, and dividing it by means of vertical and horizontal lines into sixty-four equal squares of 1 inch each. If he will then tint evenly with a very pale shade of color the upper left-hand square of the main rectangle and allow it to dry thoroughly, and then with the same tint of color wash over the two upper left-hand squares within the rectangle, and allow these to dry, and so on repeatedly until he has covered the entire area of 8 in. × 8 in., he will have in the upper left-hand corner of the main rectangle sixty-four applications of one tint, and in the lower right-hand corner, one application. The gradual and almost imperceptible grading of one square into another, from the palest shade to the darkest, will give him a valuable insight into the use of color for expressing light and shade. In trying this experiment, however, he must be sure that each successive wash dries thoroughly before the next one is applied. As this will take some time, it is well that he should not attempt to execute the whole sixty-four squares at one sitting, but paint a few at a time from day to day until the entire work is completed.

16. Pin a sheet of paper to the board as usual, and hold the brush between the thumb and middle finger, as shown in Fig. 30, steadying it with the forefinger. Dip the brush in the ink and hold it perpendicularly over the paper; draw a vertical straight line with a single movement or sweep of the arm, keeping the hand free from the paper and an even

pressure on the point of the brush; never permit the brush to become inclined in any direction, and do not allow any movement of the fingers to change the form or direction of the line, all of which should be controlled entirely by the movement of the arm. Do not draw the line as with a pencil, according to instructions given on your first drawing plate—draw it slowly and continuously, and never allow the movement to become jerky. Confine the entire attention to the execution of a single line, and pay no heed to any wavering, or apparent irregularity, as these are of no importance whatever, and often add character to the work of a designer. The main object sought should be the maintenance of a uniform width of line, by the keeping of a uniform pressure on the brush throughout the entire length of the stroke, thereby avoiding such results as shown at (*a*) in Fig. 31, which are due to a gradual increase or decrease of pressure as the stroke progresses. At (*b*) is shown a line that is of unequal thickness, due to varying pressures throughout the stroke. A line such as shown at (*c*) is not objectionable, although it is not perfectly straight; it is of uniform weight, and expresses a direct connection between two points, and is, therefore, satisfactory for brush-work design. A ruled line like (*d*), however, has no artistic value whatever, and should never be used in any other than absolutely mechanical work. Draw these lines repeatedly on separate pieces of paper until you are proficient in making them vertical and horizontal, and parallel to one another.

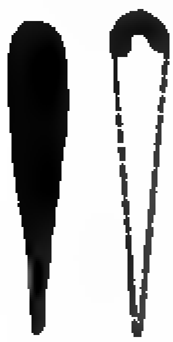

(a) (b) (c) (d)

Fig. 31.

Now repeat the first six figures executed on Drawing Plate, title, Linear Elements, carrying them out according to the rules for brush drawing instead of the rules for pen drawing. Make the lines about $\frac{1}{8}$ inch in breadth and

about 6 inches long, and execute them in one even stroke. After acquiring proficiency in this work of rendering a single even line, the student may attempt the expression of a conventional form by a single stroke of the brush. In doing this, the student charges his brush thoroughly with color, laying the point lightly on the paper, and drawing the brush toward him with an even straight stroke, gradually increasing in pressure, until at the center of the stroke he is utilizing the full width of the brush; and then decreasing the pressure until the end terminates in the point, thus producing a leaf-like form such as is shown in Fig. 32. Repeat this practice, making the forms vertical, horizontal, and inclined; then attempt the drawing of the form shown in Fig. 33 (*a*). The only difference between this and the previous figure is that its end is round instead of pointed, and the point of greatest breadth is nearer the upper end than the middle of the stroke. The regulation of this is by brush pressure entirely, but in starting a stroke of this kind it is necessary to draw with the point of the brush a short curve, such as shown in Fig. 33 (*b*), and while this curve is still wet, the end of the brush is pressed down beneath it until the hairs spread sufficiently to include it in the general stroke that follows. This form may also be drawn in the same manner as that shown in Fig. 32, the stroke being carried only half way and the lower edge being finished with a small curve. This will produce a form like Fig. 33, but upside down. Having drawn these two forms repeatedly until the student can produce them so uniformly that several of them side by side appear to be almost exactly alike, he may attempt to draw the same figures curved instead of straight, following the single and compound curves shown in Fig. 34.

FIG. 32.



(*a*) (*b*)

FIG. 33.

FIG. 34.

17. Having practiced this brush work sufficiently to become thoroughly familiar with it, the student may now attempt Fig. 1 of the drawing plate. This consists of the elements of a border, Greek in its origin, but formed entirely of single strokes of the brush; in fact, a large proportion of certain classes of Greek and Roman mural design is governed in its main characteristics by the limitations of form that can be derived from single brush strokes. Each section of Fig. 1 consists of a single stroke drawn as above explained. Preliminary to drawing Fig. 1, the student should draw the border line of his plate in pencil, and then divide the plate by a horizontal pencil line *a b*, $\frac{1}{4}$ inch above center of plate. The upper half of the plate should then be divided so as to include five figures, as follows: At distances $\frac{3}{8}$ inch and $1\frac{3}{8}$ inches from the left border line, and 1 inch and $2\frac{1}{4}$ inches below the top, lines are drawn parallel to the border lines, within which the details of Fig. 1 are drawn, as shown. To the right of the left border line, $3\frac{1}{2}$ inches, a perpendicular line is drawn to form the center line of Fig. 2. Between the center lines of Fig. 2 and Fig. 3 a space of $3\frac{3}{4}$ inches is left, and between the center line of Fig. 3 and that of Fig. 4 another space of $4\frac{1}{4}$ inches is left. In the space between the center line of Fig. 4 and the border of the plate, Fig. 5 is drawn, so that its right extremity extends to within $\frac{1}{4}$ inch of the border line and its lower left extremity extends to a point hereafter to be described. The part of the plate below *a b* is again divided by a horizontal line *c d*, and vertical lines through this lower half of the plate are drawn, dividing it into ten equal rectangles, within which the figures are drawn, as hereafter described.

The lines already drawn for Fig. 1 parallel to the border line, may now be divided by light pencil lines into six squares, the corner one being left blank, while in each of the other five is one of the devices characteristic of the border. In the center of each square draw a vertical brush stroke similar to Fig. 32 of the practice strokes just explained, but with its widest part near the top; and alternately on the right and left of this stroke, commencing at a point half way up

the square and almost touching its sides, draw a curved stroke similar to *a* of Fig. 34 of the practice strokes. Beneath these, and half way between the second strokes and the bottom of the square, draw a third brush stroke on each side the center similar to *b* of the practice strokes, thus completing one section of the border. Repeat this operation in each of the squares, as shown on the plate, being careful to keep all the strokes of uniform thickness and color with those of the preceding section.

To draw Fig. 2, the student has simply to combine a number of brush forms similar to Figs. 33 and 34 of the practice strokes, except that they are considerably larger, the entire height of Fig. 2 being 3¼ inches. This figure is also of Greek origin, and is used in various positions of mural decoration and border work, as will be seen in the execution of the next drawing plate. The governing outline of the figure is elliptical, and the student may lightly sketch an ellipse that is 3¼ inches wide and 6 inches long as the governing outline of the strokes of this figure. The top and side of the ellipse should be ⅛ inch below and ¼ inch to the right of the border lines just drawn. The outline of the ellipse above the line *a b* should then be divided on each side of its major axis into four parts similar to the division of the ellipse for the drawing of the conventionalized leaf on the previous plate. The points of division should locate the position of each brush stroke intended to compose this figure. The student, if he so desires, may draw lightly in pencil the outline of each one of these strokes, in order that he may be more accurately guided in laying the stroke with his brush; but the lines thus drawn should be so light that they will not show after the color is applied, but if they do show, do not try to erase them, as it cannot be done without reducing the tint of the color used in the brush work.

Fig. 3 is a device commonly known as the *fleur-de-lis*, which, though usually considered as typical of French design, is also found in Italian and German work, of the 15th and 16th centuries. The origin of the form is, as its name implies, the lily. The term *fleur-de-lis* literally translated

means "flower of the lily." It is extremely conventionalized, and resembles but slightly the type from which it is derived, having been reduced to its present form by the limitations imposed through brush-work rendering. To draw this figure, the student should lay off at an angle of 45° each side of its center line a distance equal to the height of Fig. 2. He should use this measurement as the side of a square, drawn lightly in pencil with his 45° triangle, as shown by the construction lines. Within this square he may draw lightly in outline the figure as shown, and then fill in the outlined form with strokes of the brush. It will be practically impossible to make each of these strokes with a single stroke of the brush; but, by charging his brush with plenty of color, and drawing first one side of the large stroke to completion, and then the other side, before the color last laid has a chance to dry, he can produce an even tint throughout the figure, as explained in the preliminary instructions on brush work.

18. After the figure is drawn, strengthen the lines with a *hard* pencil, and then clean the plate around the figure thoroughly with a soft rubber so that no cleaning up will be necessary after the brush work is done. Mix up a considerable quantity of wash ink and water in a teacup or saucer and do not be afraid of keeping it pale. Try on a separate piece of paper until the proper tint is attained, and do not determine on the tint until it is thoroughly dry. Keep it lighter rather than darker than the original plate. Be sure that the brush is full of color and lay it on liberally, keeping the board tilted so that it will be inclined to run downwards, but not so much tilted that it will run by itself unless pushed with the brush. Keep a puddle of ink on the plate below the brush at all times so that there will be no chance of its drying when you are dipping the brush in the vessel again, and push this puddle ahead of the brush until the entire surface is evenly covered. Cover each part as you go along, and never under any circumstances go back over it. If it appears wetter in one place than another, tilt the board so

that this extra moisture may be gradually drained down into the advancing brush fluid.

A few trials in this way on a separate piece of paper will surprise you with the simplicity of this operation. It requires knack more than skill, and this knack will come to you suddenly after repeated practice. Do not work too slowly, nor yet hurry. With this work there is plenty of time to do it carefully, yet one must not work so slowly as to let any portion dry until the entire figure is covered, as otherwise the tint will be uneven. When the puddle of color below the brush has reached the extreme end of the figure, the brush may be dried on a piece of blotting paper and then applied to the puddle to take up the superfluous ink, and dried again on the blotter as often as is necessary to tone down the last part.

19. With Fig. 4 we return once more to the conventionalized acanthus leaf; this time, however, though rendered on the same principle as Fig. 6 of the previous plate, it is varied somewhat to accommodate the brush-work limitations. Construct as before, in the drawing of Fig. 6 of the previous plate, an ellipse, and divide it through the center and sides in precisely the same manner as the ellipse was divided for drawing the first outlines of the acanthus leaf. On the center line of the ellipse, on the present drawing plate, draw the single brush stroke *a b*, and on each side of this stroke draw the additional brush strokes shown at *c d*, *e f*, *g h*, etc. These strokes have for their center lines the penciled lines drawn in the original subdivision of the ellipse, and the space between them is divided as shown by the single brush strokes—each complete in itself but not in any way lapping over its neighbor. In drawing this figure, let each stroke dry thoroughly before the one next to it is executed. This may readily be done by drawing every alternate stroke first, as shown on the left side of the figure, but on the student's plate the figure must be completed on both sides. A very slight lapping over of one stroke on the other will then produce a dark line, due to the double tint, which

is not objectionable if not too prominent. On the other hand, the effect of one stroke not quite meeting its neighbor will produce a white line between the strokes, which is also unobjectionable if not excessive. The main object to be sought in putting in the minor strokes is to divide them up in groups with the main stroke, so that, in each case where the main stroke reaches to the outside border line, a minor stroke will be on each side of it to fill up the space between it and its neighbor, but not extending so near the outline. The principle expressed in this figure is the same as that of the form illustrated in Fig. 28, in connection with which was explained the necessary development of leaf forms when they are to be executed in wrought-metal work. The principle of this conventionalized acanthus foliage is identical in each case, and, though many variations in its outline may be practiced, the governing lines will determine the direction and degree of radiation in the several lobes, whether the indentations on the edge of the leaf are based on a regular growth, as in this case, or on an irregular or serrated leaf, as in Fig. 6 of the previous plate. After the student has drawn and brushed in the work on this figure, he may erase the elliptical outline, but should bear in mind that both sides of the leaf are to be finished in the same manner as the right side on the drawing plate, the left side being here left skeleton in form on the specimen plate in order that the strokes may be correctly delineated.

Fig. 5 is a side view of the conventionalized acanthus leaf, rendered in brush work similar to the side view of the previous plate. The student will draw this view, starting with the stroke from *a* to *b*, showing the full breadth of the stroke at the commencement and tapering it off until the last two-thirds of it is but a mere line. The next stroke, starting at *c*, is similar to the first one, though not so sharply curved, and dies away into the first about half way down. The third stroke *d*, however, is carried all the way to the bottom. The other strokes are laid in succession, one after the other, as indicated, each one being allowed to dry before the following is laid. If the student should so desire, he may outline

the general grouping of the strokes with his pencil. In size and general proportion, this leaf is similar to the conventionalized form previously drawn, though it does not necessarily follow that it is a side view of the same leaf, the object of this work being simply to familiarize the student with his brush and his medium, or color, in order that he may give proper expression to his ideas by the simplest methods.

In the following nine figures on the plate, the student uses his brush to express natural forms, some of which he has become familiar with in his designs in pencil, though the essential difference between pencil drawing and brush drawing lies in the fact that one deals with lines and the other with surfaces.

In Fig. 6 are shown three simple flower forms, two of which are the phlox and the third the carnation. These were drawn by the student in pencil on his fourth drawing plate, and the characteristic differences in their various parts were there explained. In drawing them now, the student has but to observe that each part of the flower consists of one stroke of the brush. He may, if he chooses, draw a light pencil ellipse to limit the outline that will enclose the ends of the petals of each flower, and point off approximately five equal divisions of the circumference toward which these petals will extend. When he starts his flower form with the brush, he will lay one petal at a time, each petal consisting of but a single stroke in its general form, but it may be shaped or its edges serrated by extra touches before the original stroke dries. He will then draw the little cup at the bottom of the tubular portion of the flower, showing its characteristic points or prongs that extend upwards and grasp the tube, and then, when both the petals and the cup are dry, he will draw the connecting tube from the center of the flower to the heart of the cup, and afterwards the stem of the flower. He must be careful to give expression to the edges of the leaves or petals of the two styles of flower, as explained in connection with their original drawing in Drawing Plate, title, Flowers and Conventionalized Leaves. Though it is not necessary that the student should have

before him the natural flower from which to draw these forms, it is assumed that by this time he is familiar with the characteristics of at least a few of the principal plants, and can, without copying, give expression to their form on paper. Fig. 6, like all the following figures of this plate, with the exception of Fig. 10, is drawn approximately in the center of the square laid out in the original subdivision of the plate.

Fig. 7 is drawn in the square immediately below Fig. 6, and consists of a loose bunch of cattails or flag weed so familiar along the edges of swamps and marshes. This form is much used in many classes of design. Though the student has not drawn anything like it before, its delineation is so simple that it requires little or no botanical explanation. The stem containing the cattail stroke is nearly straight. The leaves themselves sprout stiffly from the root and curve gracefully away from each side. The stiffness of the leaves causes them to be easily broken, and it is rarely a bunch of cattails is seen that some of its long slender lance-like leaves are not broken off sharply at an angle. This sharp broken leaf therefore becomes as characteristic of the cattail weed as though it were actually a detail of its growth.

In Fig. 8 are shown two views of the common butterfly. There is no attempt made to show the gradation of the color or shading of the wings, the idea being simply to express the outline in brush form. At *a* the insect is shown with its wings spread as though flying, while at *b* it is shown as it would appear after alighting, with the wings folded up over the back. To draw this figure, the student should construct in the upper left-hand corner of his third square a trapezoid, the two parallel sides of which—top and bottom—shall be 2 and $1\frac{1}{4}$ inches long, respectively, and spaced $1\frac{3}{8}$ inches apart. The body of the insect may then be outlined lightly in pencil, with its head $\frac{3}{8}$ inch from the top line and its body $\frac{7}{8}$ inch in length. The body may then be drawn with a brush and allowed to dry, and when thoroughly dry the student may draw the wings as shown, rounding them in the corners of the trapezoid and washing from one pair of wings across the body to the other, thereby producing a

double tint for the body of the insect, while but one tint is expressed in the wings. This is the first application of brush work wherein the student has been called on to express more than one tone or shade in his wash drawings. By mixing the ink rather pale and making repeated washes over a given spot, allowing each to dry before the following one is laid, a gradation of color can be made from a very faint tint, scarcely distinguishable from white, to absolute black. In some classes of work, finer effects are obtained by repeated washes than by laying the body tint in full strength of color in the beginning.

At (*b*) in Fig. 8 the insect is shown at rest. The wings are folded straight over the back, the front wing and the back wing being brought more closely together than when flying; and, as the wings in this position show their under sides, it is the back wing that is seen lapping over the front wing, instead of vice versa as at (*a*). The outline of the individual wings is precisely the same in either case, though there is a slight difference in the body, the legs here seen grasping the twig on which the insect is resting and the full outline of the side of the body more clearly shown. It might be well to suggest that Fig. 8 (*b*) may be drawn within a triangle constructed by drawing a line diagonally through the trapezoid required for the first figure. The base of the triangle will then become one of the sides of the trapezoid, and the distance necessary to close the wings in lighting is shown by the amount it projects over the lower line of the above constructed triangle. The body itself of the insect should then be drawn independently, as its outline is quite different from (*a*).

In Fig. 9 at (*a*) is shown an insect composed entirely of single brush strokes, very familiar in Japanese design, that, though it does not bear any strong resemblance to any special living form, it combines so many characteristics of a number that for want of a better name it is termed "a conventionalized mosquito." The principle of its construction is based on the circle. The student may draw in the upper left-hand corner of the proper square of the drawing plate a

circle 1¼ inches in diameter, and divide its circumference into three equal parts. From the center of the circle to the bottom division point, a single brush stroke is made, being broad at the top and terminating at a point at the bottom. This characterizes the body of the insect. From each of the upper divisions of the circle, a similar stroke is drawn toward the center, forming the two upper wings; and below these, two similar and parallel strokes are drawn, forming the lower wings. The head and legs are then indicated in the most conventional manner, simply by two dots for the protruding eyes and four fine filaments for the visible legs. The combination of this design in geometric ornament used for wall decoration is illustrated in Fig. 35.

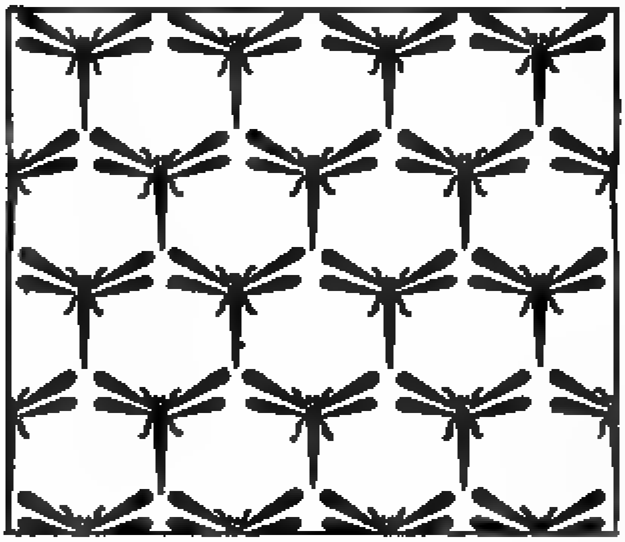


FIG. 35.

In Fig. 9 (*b*) is shown a familiar insect seen around swamps and marshes, usually termed the ***devil's darning needle***, or sometimes called a ***dragon fly***. The body of this insect is first drawn lightly in pencil so that it measures 1⅝ inches in length, and about ⅛ inch in thickness at its thickest part. The outlines of the wings may then be sketched so that they measure 2¼ inches across. The wings are arranged so that the foremost edges of the front wings and the tip of the head of the insect are on the same line. The whole surface of the fly is then washed in with a very dilute solution of India ink; and after this wash is dry, the solution of ink may be strengthened, and the darker portions of the wings and the body of the insect painted a second time. When this is dry, the lower right-hand portions of the articulations of the body may then be shaded, as shown.

This insect is introduced here to illustrate clearly the difference between conventional and realistic rendering. At (*a*) is shown a strictly conventional insect; at (*b*) is shown

an insect of the same class arranged naturalistically, or as it is usually seen in nature.

Fig. 10 is a rather elaborate combination of brush line and wash work familiar in various designs for crests, monograms, and heraldic devices. The governing outline of the figure is a simple shield, $2\frac{1}{4}$ inches wide at the top and $2\frac{1}{4}$ inches high at the center. Within this, by single brush strokes, a conventionalized silhouette of a bird is expressed, and around the outside a wavy band to receive the inscription, when such is applied. The student may, if he so desires, outline portions of this suggestively with the pencil, though a careful study of the form will show so conclusively the direction and termination of each stroke that outlining seems hardly necessary. The finer forms may be drawn with a pen, or, by careful handling, the entire figure can be executed with the brush.

Fig. 11 is a heraldic silhouette of a lion. The form is purely conventional, but by careful handling can be arranged to be expressive of life and action. The student should first draw a line 3 inches high and extending $\frac{1}{4}$ inch below the lower line of the enclosing rectangle. From the center of this, draw a horizontal line to the right $1\frac{3}{4}$ inches in length, and from the extremities of the vertical line draw lines to the point last located, thus forming an isosceles triangle standing on one corner, as indicated by the construction lines. One foot of the animal then rests in the lower corner of this triangle, while another foot rests about midway between this and the apex. Of the forefeet, the right one crosses the line midway between the apex and the base of the triangle, while the left one crosses one-quarter of the distance between the first and the apex above. The ear is in the uppermost corner of the triangle, and the entire face extends outside, so that the side of the triangle passes even with the edge of the lower jaw. The hollow of the back is $1\frac{1}{4}$ inches below the top of the ear and $\frac{1}{4}$ inch to the right of the vertical line. By way of checking the measurements, it might be noted that the back of the lion is $\frac{3}{16}$ inch from the vertical line, measured on the horizontal line marking the altitude of the triangle, and on this same horizontal line is $\frac{3}{8}$ inch in

thickness. Having outlined the figure carefully in pencil, the student will wash it in with one even tint, allowing the same to dry, and then going over the darkened parts as shown to give expression to the details. If a second wash is not sufficient to accomplish this, he may give a third or even a fourth one; but, as soon as the detail is defined and the drawing expresses what is required, do not apply any further wash work, but consider the figure complete.

Fig. 12 is another heraldic device based on a style of design usually termed *grotesque*. In this work the attributes or elements of several different classes of animals are often combined. This example illustrates a figure that might be properly called a *dragon*, and though there are many different kinds and conceptions of this mythical form, they all usually possess the body of some reptile, the feet and claws of a feline animal, the wings of a bird or occasionally of a bat, and the head of a carnivorous bird or beast.

To draw Fig. 12, construct, 4 inches from the right border line, a square 2 inches each way, whose base is $1\frac{1}{4}$ inches above the lower border line; $\frac{2}{3}$ inch from the right and left sides of this square, and within it, draw two vertical lines, thus converting the square into three rectangles each $\frac{2}{3}$ inch wide by 2 inches high. Now draw a horizontal line through all three rectangles and $1\frac{1}{8}$ inches below the top. These lines are shown on the drawing plate, and by comparison and eye measurement the student may outline in pencil the general proportions of the grotesque figure.

The head is located on the right vertical line of those drawn within the square, and the neck curves to the left and just crosses the next line to the left of this. In crossing into the lower right-hand rectangle, the line of the back of the neck practically passes through the intersection of the vertical and horizontal lines, just below which point the outside of the body comes within $\frac{1}{8}$ inch of the right side of the square. The foot then extends outside of the square $\frac{1}{4}$ inch, and $\frac{3}{8}$ inch above the horizontal line. The upper portion of the wing is an evenly curved line, extending into the upper left rectangle as shown, but is ragged on its lower edge.

The tail extends outside of the square, turns over, and ends with a scroll termination 2½ inches to the left of the square. After the figure has been outlined, the student may wash it in and shade the individual parts as in the previous figure, indicating a roughness on the under side of the wing in the same manner as he indicated the feathers in Fig. 10, and drawing scales by means of triangular brush marks on the lower part of the body. When the figure is complete and dry, the drawing medium should be thinned down somewhat, and the brush strokes that form the background should be drawn in without too much color in the brush, and care taken that their curves follow and radiate from the general curvature of the body. When all is dry, carefully erase the guide lines.

Figs. 13 and 14 are additional devices frequently seen in heraldry, and are drawn in precisely the same manner, so far as the brush work is concerned, as the two previous ones. Fig. 13 represents a dolphin, engraved upon a shield. This device is used in various forms as a part of a coat of arms of many foreign families, particularly the ancient royal families of France. The shield on which it is drawn is 2¼ inches wide at the top and 2¼ inches deep to the bottom. The distance from the outline of the dolphin to the nearest point in the outline of the shield at the top and sides is ¼ inch, while the extreme height of the fish from top to bottom is 2 inches. The student may outline this figure carefully in pencil, and with a harder pencil strengthen up the lines after it has been drawn to his satisfaction; and then, after cleaning up the drawing, he may wash in the background to form an even tint as shown, with the dolphin device silhouetted against it in white.

The size of the shield in Fig. 14 is the same as that in Fig. 13. The figure here is a combination of the lion's body with the eagle's head, claws, and wings, and is usually known as a *griffin*. Another device in heraldry known as the *panther* is almost precisely the same as the griffin, but without the wings. A vertical line through the center of the shield will pass through the left foot and the center

of the top of the head of this figure, while a line through the upper right-hand corner of the shield drawn to the left at an angle of 45° will give the direction of the upper slant of the wing, and pass through the knee and above, and parallel to, the lower extended fore leg and claw. A similar line drawn through the upper left-hand corner toward the right, at an angle of 45°, will mark the direction of the upper fore leg and claw, and also the direction of the slant of the upper portion of the left hind leg. These points located, the student should have no difficulty in outlining the general figure in pencil, after which he may erase the guide lines and carefully wash it in with his brush, making it in silhouette on a white shield—the reverse of the one above. The shield may be outlined with a pen, using ink in full strength.

There are many variations of all these animals and imaginary figures that combine the distinguishing characteristics of beasts, birds, and fishes; they all enter largely into the devices used in heraldry, though their more frequent mission in nineteenth-century design has been to suggest subjects for ornament in stone, plaster, and iron, and even to suggest devices for the ornamentation of burnt-leather work and ornamental advertising. Their original purpose in heraldry they have outlived so far as origin of design is concerned, each particular heraldic device or coat of arms requiring a particular form of beast or imaginary figure that is unalterable without varying the characteristics of its own coat of arms.

After finishing this plate as above described, the student will carefully erase the construction lines, draw in the border line in ink as before, carefully print the title at the top of the plate, and then insert his name, date, and class letter and number in their usual locations below.

DRAWING PLATE, TITLE: APPLIED DESIGN.

20. It is the purpose of this plate to give the student a few examples from actual designs, both classic and modern, wherein the principles taught on the previous plates are

ED DESIGN.

Fig. 4

Fig. 3.

Fig. 2

Fig. 5.

distinctly applied; and in studying this work it will be to his advantage, not only to study the application of the different points of design, as they are set forth in the instructions for this drawing, but to study similar applications in other designs, whether he finds them in printed books, in woven cloths or carpets, or on painted vases or chinaware.

In Fig. 1, we have a border showing the application of a vine, and although on this plate it is executed as a silhouette design, its application for inlaid woodwork, for embroidery work, or the theme of its design for the border of any printed program or advertising work, is very apparent. This style of ornament is easily executed, and for certain classes of printed work is particularly desirable, because, owing to the absence of any fine lines, it is subject to extensive duplication in the printing process without injury to the original plate. The design may also be executed with the white figure on a dark ground, and it is always left to the designer's judgment which style of treatment would be the more satisfactory. All the figures on this plate are in black and white, and the student in blacking them in will use his brush well charged with the waterproof drawing ink, using it full strength, and without diluting or attempting to spread it thinly, as on the previous plate.

To draw Fig. 1, the student will draw parallel with the left border line, and 1½ inches from it, a vertical line from the top to the bottom of his plate; parallel to the top and bottom border lines he will draw horizontal lines about 6 inches in length and 1½ inches from them.

Omitting for the present the square formed in the corners by the intersection of these lines, the student will draw horizontal lines through the vertical panel formed on the left of his plate, so as to divide that panel into four equal parts, these lines being indicated by the dotted lines on the drawing plate. The winding of the stem of the morning-glory vine can then be readily traced, and if the subdivisions so marked are repeated horizontally on the top and bottom of the plate, the design may be repeated within their limits, and the curved line through the corner square will connect

the ends of the stems where, with the corner leaves drawn in as shown, the border repeats itself continuously.

No directions are necessary here for the drawing of the convolvulus or its leaf; the outline and characteristics of each of these the student is supposed to have learned in executing his third and fourth drawing plates. His attention is only called to the fact that, in outlining these leaves and flowers, the lines are arranged somewhat stiffly, and, instead of curves, angular bends are expressed in the leaves, in order to make the design appear somewhat more conventional. Where a flower laps over on the leaf or crosses the stem, or where one stem crosses another, it is customary under these circumstances of conventionalism to indicate it by breaking the stem, leaf, or flower on each side of the continuous detail, leaving a fine white line across the stem or flower to indicate which laps over the other. The veins of the leaves and the suggestion of the heart of the flower are also here expressed in white. This white work, however, is not left clear when the design is drawn, nor scratched out afterwards, but after the design has been blacked in solidly from end to end, an ordinary writing pen charged with white water-color paint (usually Chinese or zinc white) is used to mark the veining and the crossings and lapping over of the details. Chinese white may be obtained either in cake form, like ordinary water colors, or in a pasty form in bottles. In the former case, it is prepared for use by grinding in a saucer or on an ink slab in the same manner as stick ink, as described in *Geometrical Drawing*. In the latter case, it is simply diluted with enough water to bring it to the proper consistency for use; occasionally a drop of dilute ox gall is added to the solution to make the white paint flow easily.

The term "repeat" in any form of design is used to express the quality of the design for continuity by extending itself with a given variety over a given surface, and then fitting on to a repetition of itself again so as to form a correct geometrical continuation of the pattern. In carpet and wall paper the quality of repeating is generally termed

matching, and is illustrated when the edges of two pieces are brought together so that the design continues unbroken from one of them to another, and the designer of this character of goods is required to give this fact his constant consideration whenever he is laying out any pattern.

In Fig. 2 is shown a panel, the design of which is based on the growth of the lily. The size of the panel is $2\frac{1}{4}$ inches wide by $7\frac{1}{2}$ inches high, and it is located so as to be surrounded by the morning-glory border previously drawn, as shown on the plate. In drawing this figure a center line should be drawn vertically through the panel, and on this center line the height of the panel should be divided into fifteen equal parts, through each of which a horizontal line is drawn, as shown. The dividing of the space on each side of the center line into three equal parts through which other vertical lines are drawn will reduce the surface of the panel to a series of rectangles, by means of which each detail of the design may be accurately located. After the student has outlined all of his work on this panel carefully, he will find it an advantage to ink it in with waterproof drawing ink; then, when he is washing in his black background, he will find the brush less inclined to run over the ink lines and destroy the evenness of his contours than if he had nothing but pencil lines to guide him. After the entire background is washed in and dry, the veining and suggestive shading of the leaves and blossoms may be put in with a fine brush or pen. The stamens may be put in with Chinese white.

By comparing this conventionalized design with the drawing of the lily on the third freehand plate, the student will observe a variation. In the first place, the leaves are rather broader than on the previous plate, as this class of lily has broader leaves; but their characteristic form is maintained the same, and the blossom, though seen in two different positions, expresses the characteristics of the lily development so clearly that there is little or no danger of mistaking the design. This design is rather too conventional for embroidery work, but for wood inlay or damask weaving it is easily adaptable.

In Fig. 3 is shown a design that is applicable either to china decoration, embroidery, or linen damask work. The governing form of the design is a circle with its center 4½ inches below the upper border line of the plate, and exactly midway between the two side border lines. The student may draw a circle 5 inches in diameter, and divide it into eight equal parts, to each of which he will draw from the center eight radial lines. Then, with a radius of 2⅜ inches, he will strike from the same center a circle that will form the outside of his ornamental design, while a circle drawn from the same center, with a radius of 1¼ inches, will limit the inside of the design. On each of the radial lines thus drawn the student will first draw the foliated brush forms *a b*, *c d*, etc. according to the methods practiced on the previous drawing plate, except that the ellipse governing the outside limits of these forms has its longitudinal axis at right angles to the perpendicular axis of the figures *a b* and *c d*, as the enlarged detail, Fig. 36, will show. Having carefully sketched the ellipses as shown in Fig. 36, the student may draw the brush marks that indicate the leaves on this figure, being careful to extend the central brush mark nearly to the outside line. He will then divide the distance from *a* to *b* into nine equal parts, and through each of these points of division draw a circle with its center at *o*. The arc from *a* to *c* will then be divided into nine equal parts, through

each of which radial lines should be drawn toward the center *o*. This will divide the surface *a b c d* into eighty-one similar geometrical figures, by means of which the details of the ornament can be radially located. When all is carefully drawn in, in pencil, throughout the entire circumference of the plaque, the student may brush in the design in black ink, as shown, and complete the figure. The outer circle should be inked in with the compass, the other construction lines being erased.

Fig. 4 is an ornament taken from the ceiling of the Parthenon—a Grecian temple at Athens considered to be one of the finest examples of Grecian art the world has ever seen. The original of this ornament was executed in gold on a red ground—a condition of coloring impossible to express here, but as a practical example of brush work, nothing could be more serviceable. To draw it, locate the line *a b c* 1⅝ inches from the border line, and between this line and the border line draw a line ⅛ inch above and to the right of *a b c*. This line and the border line will then together establish the limits of the border outline. Commencing at the corner *b*, lay off to the left and below, a distance of ⅞ inch. Draw a vertical line in the upper part and a horizontal line in the side part of the border, and from the lines just drawn space off two additional lines 1½ inches apart in each direction, to form the centers of the palmettes that are the distinguishing features of the border. With the center lines of these palmettes as the upper part of the longitudinal axis, draw ellipses whose transverse axes are ⅞ inch below the top of the palmette, and 1¼ inches in length, and within these ellipses so drawn construct the brush forms of the border according to directions given in connection with the previous plate. Having done this, draw ⅝ inch inside of, and parallel to, *a b c*, the inner line of the border, and ⅛ inch within this and parallel to it, draw two lines that shall form the upper and right side of a square that will be 3⅝ inches on each side. Divide this square vertically and horizontally, by means of perpendicular and horizontal lines, into three equal parts, thus converting it into nine smaller squares within each of which distinguishing

characteristics of the panel ornament are drawn. In each of the four squares in the center of each side of the main square, circles may be drawn with the compasses $1\frac{1}{8}$ inches in diameter, or as near thereto as will make them tan-

FIG. 37.

gent to the lines of the squares. The palmette figures in the corner squares may then be drawn similar to those in the border, the other details being too apparent to require description.

In drawing the ornament of Fig. 4, which is commonly known as the Greek honeysuckle ornament, it is more than evident that its conventionalized condition is due as much to the limitations of brush stroke rendering as to an accurate portrayal of the details of the flower or plant. The little scrolls and connecting lines are suggestive of the tendrils of the honeysuckle, while the single brush strokes with their rounded ends tapering off to the finishing are strongly suggestive of the unbroken bud as seen in the honeysuckle blossom. Fig. 37 shows a spray of the honeysuckle vine and its blossoms in its natural growth. In the upper part of this figure there is a cluster of the unbroken buds, and their resemblance in outline to the plain brush stroke of Fig. 4 of the drawing plate is readily apparent. Fig. 38 shows a conventional rendering of the honeysuckle, the blown buds being arranged geometrically around the bottom, and the unbroken ones above, each over the blown flower beneath. There is no attempt in the Greek ornament to imitate directly any portion of the honeysuckle vine or flower; the details of the flower are readily made use of to form a new and original ornament resembling directly nothing, but at the same time dependent entirely on a natural form of growth. Having completed this figure, the construction lines may be erased, leaving only the line *a b c* and the one next within it, to be inked in with the ruling pen.

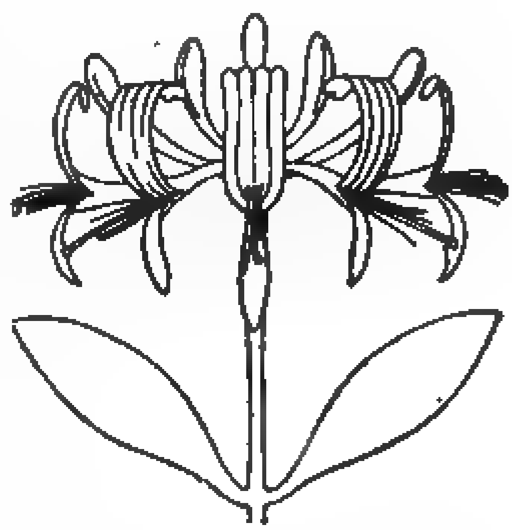


Fig. 38.

In Fig. 39 is shown the acanthus leaf, according to the Roman conventional design, as it appears in carved stone or marble; each lobe of the leaf is carefully rounded on the end, and the under surface is hollow; then, where the leaf turns over at the top, and the back is shown, each lobe appears with its convex side forward. Where the main divisions of the leaf curl and lap over each other, deep hollow grooves are cut that show in the reproduction as heavy black

lines. Observe that deep undercut portions of the leaf cause a black shadow and impress the mind generally as with total absence of detail. Now, when it became necessary to reproduce this carved form of acanthus by simple brush strokes, the Roman artist made a stroke for each lobe of the leaf and left a blank space to represent each spot where there was absence of detail—owing to deep shadow—rendering his brush-work acanthus leaf as it appears in Fig. 5 of the drawing plate.

FIG. 39.

In drawing this figure, the student should observe Fig. 40, and compare each stroke carefully with the carved ornament illustrated in Fig. 39. Before commencing the figure itself, he should, on the plate, construct a semiellipse as its outline, whose minor axis shall be 3¼ inches, and half of whose major axis shall be 5 inches, and on a line directly under the center of Fig. 3. This semiellipse is shown dotted around the figure on the drawing plate. The central rib of the leaf, which is ⅛ inch wide at *a*, should then be sketched in pencil, tapering off so that it would reach to a point at the top of the ellipse *b*, if it were continued that far. The curved line at the top of the leaf *d c e* is then drawn, and may be the arc of a circle whose radius is 2¼ inches and whose center is 1½ inches above *b*. Then draw the first brush stroke under *c*, 1⅛ inches in length. This will also regulate the length of the middle rib *a*. The points *f* and *g* should then be located

FIG. 40.

$3\frac{1}{2}$ and $1\frac{3}{4}$ inches above the bottom of the leaf, respectively. The lobes may then be sketched in with a pencil, as shown in Fig. 40 at *a*, only roughly, however, and the conventionalized form finished with single brush strokes as shown at *b*, each one representing a lobe existing in the carved leaf, as shown in Fig. 39.

Fig. 6 of the drawing plate shows a square pattern for a repeating design suitable for wall paper, silk, or other fabric,

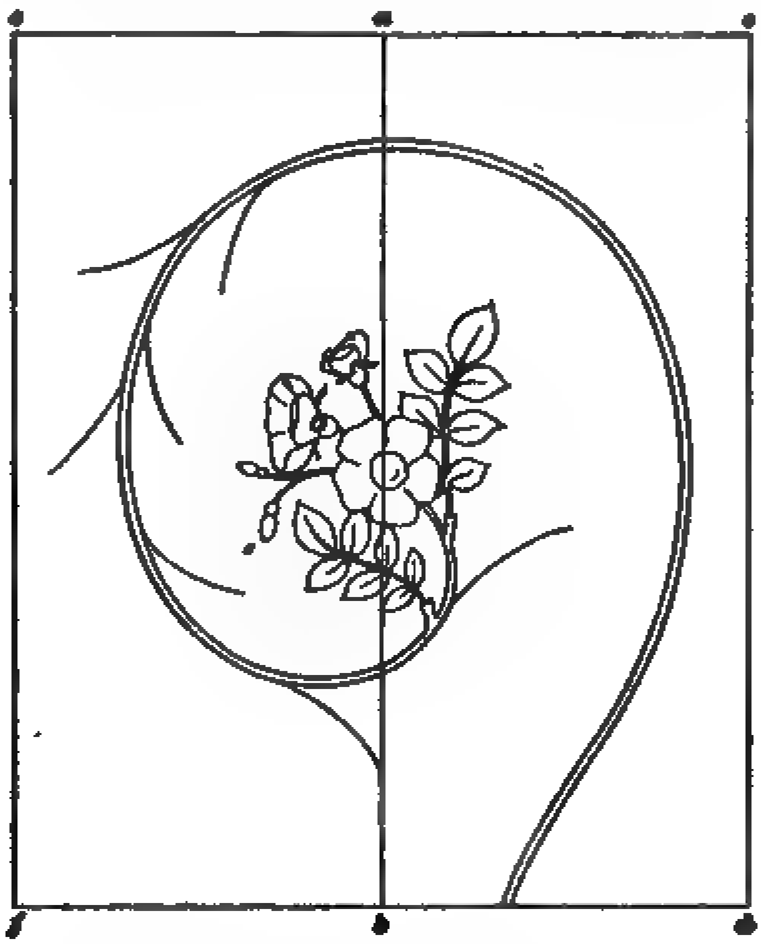


FIG. 41.

and involving the characteristics of the rose, studied in connection with the Drawing Plate, title, Flowers and Conventionalized Leaves. In all designs for repeating patterns, the designer usually uses a paper that has been ruled by machinery into a number of squares, varying in size from $\frac{1}{16}$ to $\frac{1}{8}$ inch. By means of these squares he is able to locate certain details at the top and bottom of his paper, so that the design will repeat as previously explained. It is not necessary that the student should use such paper in drawing

this figure, but it is absolutely necessary that he should draw it separately and completely on another sheet before he executes it on his drawing plate. In doing this, it will be necessary for him to understand a practical method of getting the *repeat*, and though this does not form a part of this branch of drawing, it will be here explained for this problem only, in order that he may better grasp the subject.

On a separate piece of paper, the student will lay out a

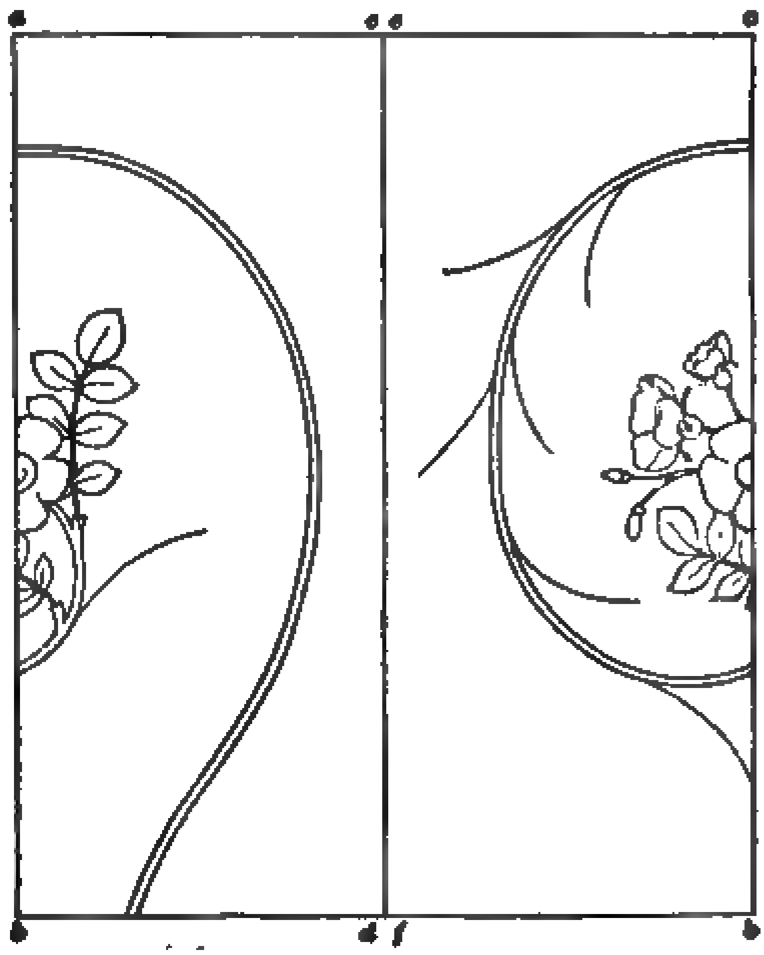


FIG. 42.

rectangle $5\frac{1}{4}$ in. $\times 6\frac{1}{2}$ in.; in this he will draw a spray of rose leaves and a blossom, with the outline of the running vine about as shown in Fig. 41. It makes no difference for this purpose how well these leaves are drawn, or how roughly they may be sketched, as long as their general location and proportion to the paper is about as shown. The student will then cut the paper in two with a pair of scissors on the line *a b*, and arrange the two parts so that the edges *c d* and *e f* are next to each other. He will then again pin the paper

to his drawing board, and it will appear as in Fig. 42. It will be well for him now to draw two more sprays of roses, or partial sprays, to fill up the blank space in the center of the sheet, somewhat as shown in Fig. 43, and having done so he will cut Fig. 43 through on the line *g h* and arrange the pieces, with the lines *a a′* and *b b′* together in the middle, as shown in Fig. 44. This will give him an idea of the amount of surface he has covered with his design; it will

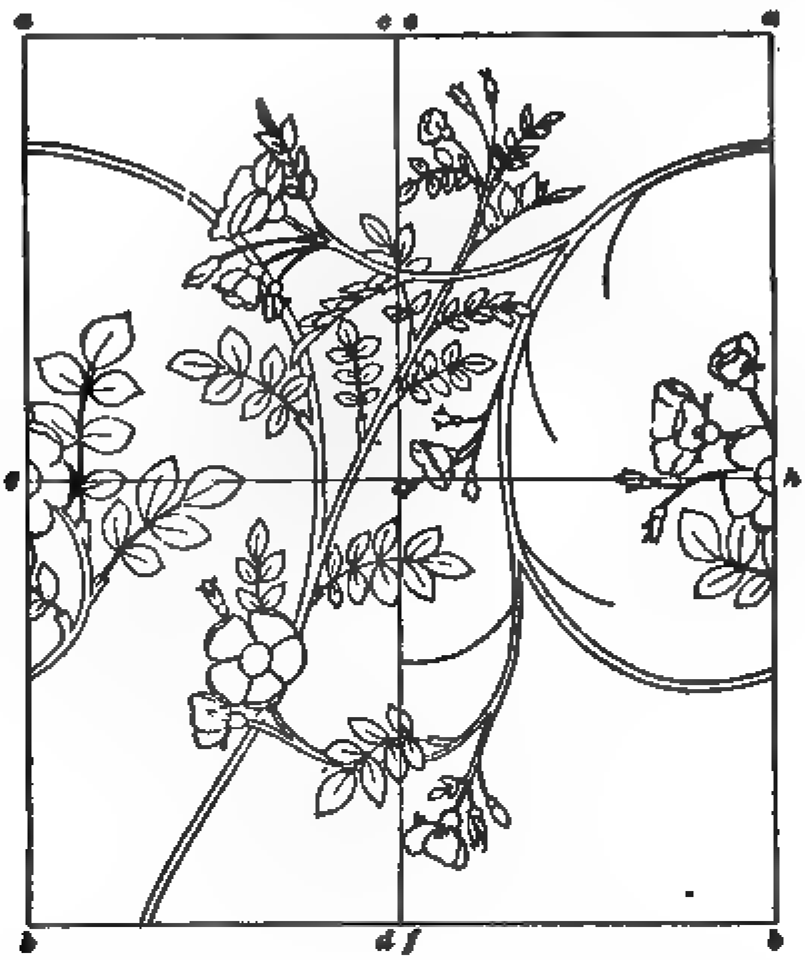


FIG. 43.

show him where more detail is required in order to evenly fill the space, and that detail he can sketch in, but wherever it crosses either one of the center lines in Fig. 44, it will be necessary to rearrange the pieces in order to get its relative position in the other arrangements. Having accomplished all this and sketched the extra details in, as shown in Fig. 45, he can rearrange the four pieces to their original positions in Fig. 41, and make a tracing of the drawing, which will now be a completed pattern as shown in Fig. 40. Several

tracings of this figure on the same sheet side by side, one above the other, will make a repeating pattern that can be spread out, above or below, to the right or left, unlimitedly, as one side of the drawing fits exactly on the other, and all details will be continuous. This is but one of several methods of accomplishing this same purpose, and the same spray of roses with which we started in Fig. 41 would produce different results by varying the methods.

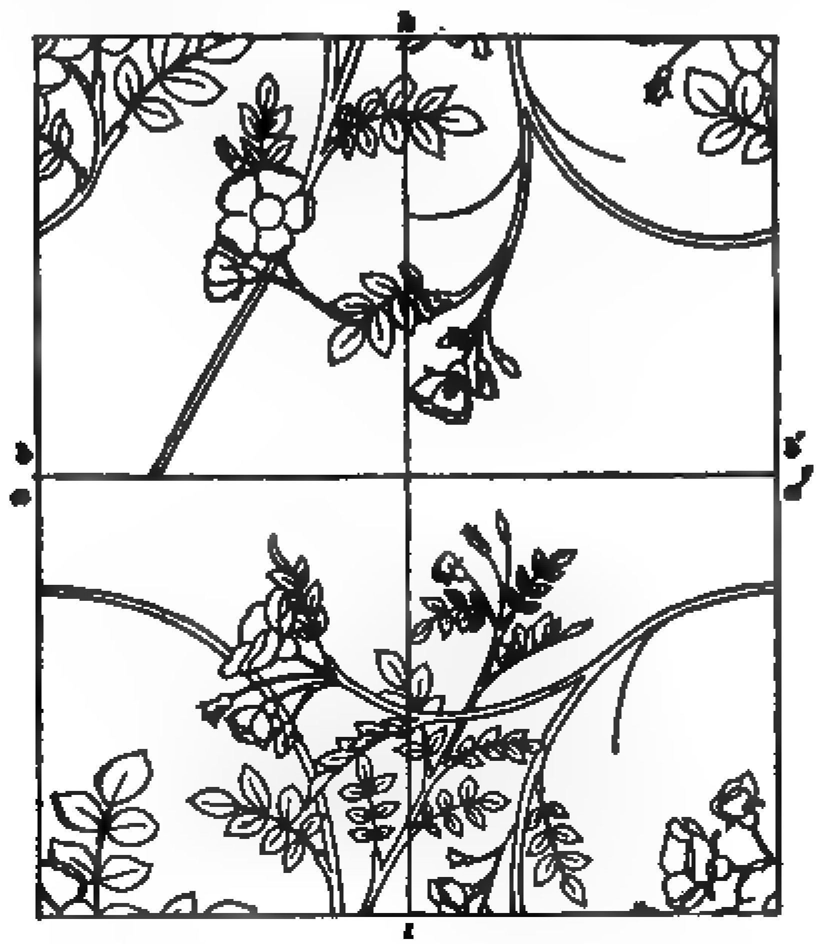


FIG. 44.

For instance, if instead of drawing our design in a rectangle, we should draw it in a parallelogram whose length was equal to 1½ times the breadth, or if we draw it within a triangle of any dimensions, or within a rhomboid, or within any other figure that is capable of unlimited repetition, we would find the results obtained to be as different as were the figures themselves, the running pattern taking different directions. Now, after the student has, on his separate paper, designed Fig. 6 of the drawing plate as shown, traced

it and tested it to be satisfied that there is no error in the repeat of his pattern, he may redraw the result of his tracing on his drawing plate, being careful that the parts are accurately reproduced. He may outline the figures with waterproof ink and black in the background with his brush to produce the silhouette effect shown in the figure (the thorns may then be indicated with Chinese white); after which he will place the title at the top of the plate, and his name,

FIG. 45.

date, and class letter and number at the bottom, below Figs. 1 and 6, but he may omit any border line entirely.

This completes this course of instruction in freehand drawing. The principles of freehand drawing set forth in this work simply require practice to make an expert draftsman. No person can acquire any accomplishment without diligent and persistent work, and the difference between a medium and a good designer is seldom more than a question of practice. After having finished this work, even though the

student's drawing plates have been correct and marked satisfactorily, it will be an advantage to him to deliberately go over the entire course again for his own satisfaction, to practice more on details that proved difficult for him in the beginning, and to make sketches of objects of various kinds whenever the opportunity presents itself, and particularly of those objects that are illustrated in the last six drawing

FIG. 48.

plates. If he starts at the beginning, or near the beginning, and goes through his instruction again, he will be surprised and encouraged at the facility he has acquired during his course of study, and it is wise for him to thus encourage himself in order that he may have the patience to continue practicing, and thus always be making progress. The student is now supposed to know how to draw and he is ready to take the first step in the study of design.

ELEMENTS OF PERSPECTIVE.

INTRODUCTION.

OBJECT OF PERSPECTIVE DRAWINGS.

1. Classification of Perspectives.—A perspective drawing of an object is a representation of that appearance, in outline, that an object presents when observed from a given point. If the perspective is rendered in outline only, then it is known as an **outline** perspective, but if it is shaded, in order to express the light values of different parts, it is a **shaded** or **rendered** perspective. A perspective drawing may thus be rendered in "black and white," as with crayon, pencil, or India ink, or it may be rendered in color. A photograph of an object is a perspective rendering of that object in black and white, and a similar effect may be obtained by a combination of lines and shaded surfaces, the proportions of which are readily learned through graphical methods.

2. All objects are bounded by plane or curved surfaces and all surfaces are limited by lines. Therefore, the drawing on paper of these limiting lines, as they appear to the eye, determines the apparent shape and area of any surface; and the grouping of all the visible surfaces bounding an object produces a perspective rendering of that object.

3. The Picture Plane.—A perspective drawing is, in some respects, similar to a projection drawing, and the plane on which the drawing is expressed is assumed to be *between the eye and the object.* In perspective drawing this plane is called the **picture plane,** and the point from which the object is viewed is called the **station point.**

SIZE OF PERSPECTIVE.

RELATION OF ANGLE OF VISION TO SIZE OF PERSPECTIVE.

4. The relative sizes of the parts of an object, as expressed on the picture plane, are dependent on simple mathematical rules that determine the apparent sizes of different objects, according to their distances from the eye.

Referring to Fig. 1, if it is assumed that lines are drawn from each side of the sphere $b\,c$ to the eye at e, and that these lines are intercepted by a transparent plane, as shown at $a\,f\,g\,h$, the circular outline connecting the points $b'\,c'$

FIG. 1.

where the lines $e\,b$ and $e\,c$ pass through the plane $a\,f\,g\,h$, will form, on this intercepting plane, an outline of the sphere $b\,c$, but which is smaller in size, according to the distances that the plane $a\,f\,g\,h$ and the sphere $b\,c$ are from the eye.

5. From this it will be seen that the nearer an object is to the eye the larger it will appear on the picture plane, as

shown in Fig. 2, where *a b* and *c d* are sides of two rectangles and are of the same length, but their apparent sizes on the picture plane *f g h j*, as viewed by the eye at *e*, are different;

FIG. 2.

the line *c d*, being nearer the eye, appearing larger, as shown at *c′d′*. From this we deduct the following rules:

Rule I.—*The extent of any linear dimension of an object, as seen on the picture plane, is inversely as the distance of that object from the eye.*

Rule II.—*The area of any given surface on the picture plane is inversely as the square of its distance from the eye.*

Thus, in Fig. 2, *a b*, being double the distance from *e* that *c d* is, appears only one-half the size of *c′ d′* on the picture plane *f g h j*, as shown at *a′ d′*; and the area of the rectangle *a b l k* appears on the picture plane only one-fourth the area of the rectangle *c′ d′ n′ m′*, as shown at *a′ d′ l′ k′*, as each of its dimensions is apparently reduced one-half. If the distance *e b* were four times the distance *e d*, *a′ d′* would then appear only one-fourth *c′ d′*, and the area *a′ d′ l′ k′* would then be but one-sixteenth the area *c′ d′ n′ m′*.

6. This is illustrated in a practical way when one stands in the center of a straight section of railroad track. On looking up the track, the rails appear to converge and meet in a point in the distance, as shown in Fig. 3, while on looking above at the wires on the telegraph poles, they appear to converge and disappear in the same point, and in the same

manner the lines of the fence boards at the sides of the track all diminish and finally disappear in the distance in a similar manner. The apparent width of the track obeys the first

FIG. 3.

rule just set forth, and the rails finally meet in a point at an infinite distance away.

7. To carry this illustration further, let us assume that we have an open landscape with a railroad track in it as shown in Fig. 4, and that in a vertical position on the ground we stand a semitransparent screen, such as is shown at *a b c d*; then, standing back of the screen and in the center of the railroad track, we view the landscape through the screen, with the eye at *S*. The semitransparent screen is then the picture plane and the station point is at *S*. Imaginary lines drawn from the eye to each of the prominent features in the landscape will pierce the picture plane at certain points, which points being connected by actual lines, will render a

FIG. 6

linear or outline perspective of the scene before us, each line of which will coincide with and cover its corresponding line in the actual scene.

8. For instance, in Fig. 4, a line *f S* from the upper right-hand point of the signal bridge at *f*, to the eye at *S*, pierces the screen at *f'*, and the line *g S* from the lower right-hand point of the signal bridge, to the eye at *S*, pierces the screen at *g'*. The upper left-hand point of the bridge at *h* and the lower left-hand point of the bridge at *j* form the ends of lines drawn to the eye *h S* and *j S* that pierce the screen at *h'* and *j'*. Lines connecting the points *f'*, *g'*, *h'*, *j'*, therefore, cover and coincide with the respective lines between these points on the bridge itself and establish the outline of this bridge as seen upon the picture plane. In the same manner, the points *k*, *l*, *m*, and *n* of the ridge, and eaves of the roof over the little tool house are expressed in the perspective on the picture plane by the points *k'*, *l'*, *m'*, and *n'*, where the lines *k S*, *l S*, *m S*, and *n S* pierce the picture plane *a b c d*.

APPARENT CONVERGENCE OF PARALLEL LINES.

9. Horizontal lines that are parallel to the picture plane always appear parallel in perspective, as shown by the ties of the railroad track, which appear to diminish in length and in distance apart, but remain parallel to each other, until they disappear in the distance. The same is observable in the telegraph poles and fence posts. Hence, we deduct the following rules:

Rule III.—*All lines, whether vertical, horizontal, or inclined, when parallel to the picture plane, retain their normal directions in perspective drawing.*

Rule IV.—1. *All lines not parallel to the picture plane, but parallel to one another, appear to converge as they recede from the eye. The point toward which any set of parallel lines converges is called their vanishing point.*

2. *When the parallel lines are perpendicular to the picture plane* (as the rails, telegraph wires, and fence boards, in Fig. 3), *the vanishing point is directly in front of and on a level with the eye; in this position it corresponds with the center of vision.*

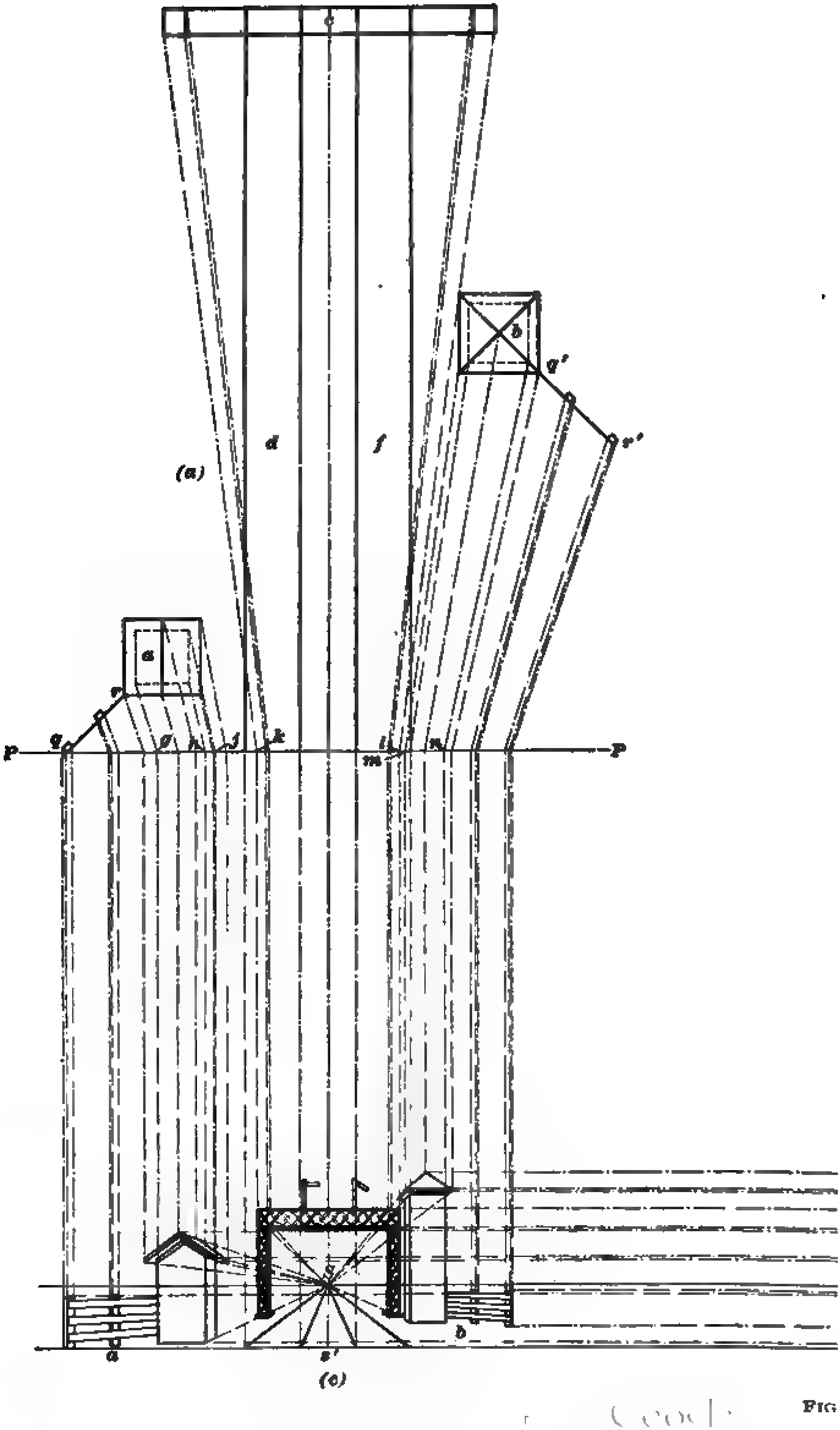
Hence, lines perpendicular to the picture plane and below the level of the eye slant upwards, as shown by the rails, and lines above the level of the eye slant downwards, as shown by the telegraph wires.

The horizontal line through the center of vision is called the **horizon,** and the line from the eye to the center of vision is called the **axis,** or **line of direction,** and the extent of the view that is included on all sides of the line of direction is called the **field of view,** or **angle of view.** As the eye is only capable of including about 60°, the field of view is usually limited to include but 30° each side of the line of direction. When so limited the field of view is termed the **visual angle,** or **scope of vision.**

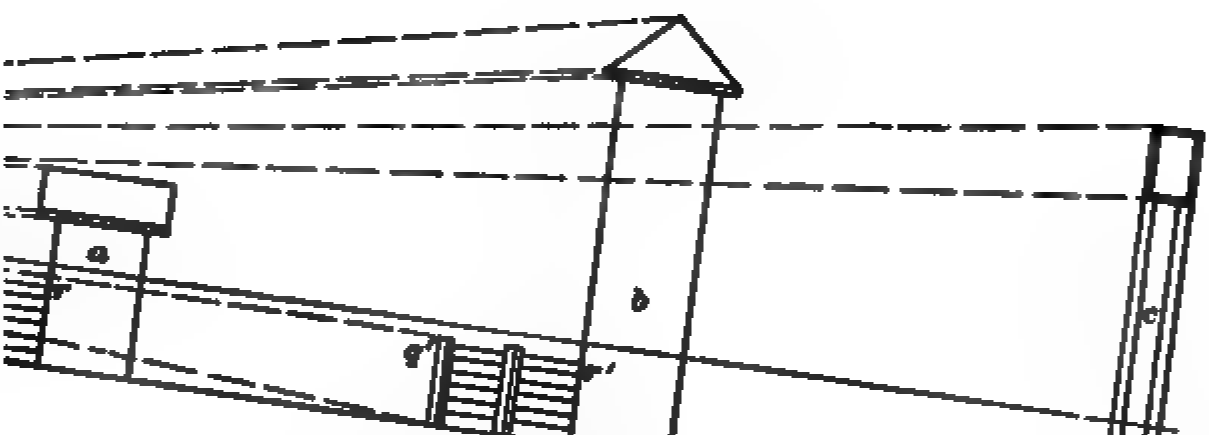
Rule V.—1. *When the parallel lines are horizontal, but at an angle with the picture plane, their vanishing point is on a level with the eye, but to the right or left of the center of vision, according to the angle that the lines make with the picture plane.* As shown by the fences at *r* and *s* in Fig. 4.

2. *When the parallel lines are horizontal and incline at an angle of 45° to the picture plane, their vanishing point is to the right or left of the center of vision,* **a distance equal to the distance of the station point from the picture plane.**

10. In Fig. 5 (*a*) there is shown a plan or survey of the ground represented in the illustration in Fig. 4. At *a* is the tool house, at *b* the signal tower, at *c* the signal bridge across the railroad tracks, and at *d* and *f* the tracks themselves. The line *P P* represents the plan of the picture plane, and at *S* is the station point. If lines are now drawn from the corners or prominent points of each of the details



FIG



(b)

of the plan toward the station point at *S*, they will establish, where they intersect the picture plane *P P*, the relative values of these details in the picture. For instance, *g h* represents the perspective breadth or proportional width of the tool house on the side nearest the eye, while *h j* represents the width of that side of the tool house that recedes from the eye toward the distance. *k l* represents on the picture plane the length of the signal bridge *c*, and in the same manner *m n* shows the perspective width of the signal tower *b*. Thus, all the details of the picture can be laid out according to their actual dimensions, and projected by means of lines toward the station point so that their perspective dimensions may be obtained *in plan* upon the picture plane *P P*.

11. In Fig. 5 (*b*) is shown a side elevation of the same scene, the tool house being located at *a*, the signal tower at *b*, and the signal bridge at *c*, making their distances from the elevation of the picture plane *P' P'* in Fig. 5 (*b*) the same as they were from the plan of the picture plane in Fig. 5 (*a*).. The station point *S* is located the same distance in front of the picture plane that it was in Fig. 5 (*a*). Lines drawn from the visible extremities of the details in Fig. 5 (*b*), toward the station point at *S*, indicate the perspective heights of these details on the picture plane *P' P'*, Fig. 5 (*b*), in the same manner as the perspective widths were indicated in Fig. 5 (*a*).

12. It is, therefore, evident that the composition of geometrical figures wherein the heights of the objects are taken from the picture plane in Fig. 5 (*b*) and the widths of the same objects are taken from the picture plane in Fig. 5 (*a*) will give us the perspective dimensions of each detail, as shown in Fig. 5 (*c*), where lines drawn from *g h* perpendicular to the picture plane *P P*, Fig. 5 (*a*), intersect with lines drawn from *g h* perpendicular to the picture plane in Fig. 5 (*b*) and establish points that determine the lengths of certain details in perspective.

13. It will be observed that Fig. 5 (*c*) is a representation of views (*a*) and (*b*) that was obtained by means of this system of projection. First, the projection of the dimensions of the object on the picture plane was obtained; second, the views of these objects were reconstructed by the dimensions so obtained. In order to do this, it is necessary that the vanishing point of all horizontal lines perpendicular to the picture plane should be located. This point, as said before, is the center of vision and is always on a level with the eye and directly in front of the observer; therefore, for convenience in this case, we make the center of vision of Fig. 5 (*c*) coincide with the station points used for Figs. 5 (*a*) and (*b*).* The rails of the tracks and all lines parallel to them converge toward this center of vision, thus determining the direction of all horizontal lines perpendicular to the picture plane.

14. In the plan, or survey, Fig. 5 (*a*), there are shown at $q\ r$ and $q'\ r'$ two short pieces of fence that extend at an angle of 45° with the picture plane. These pieces of fence are shown in elevation at $q\ r$ and $q'\ r'$ in Fig. 5 (*b*). Now, it was stated in rule V that when horizontal lines incline at an angle of 45° with the picture plane, their vanishing point is the same distance from the center of vision that the station point is from the picture plane. Therefore, if we lay off to the right of S a distance $S\ x$ equal to the distance that the station point S is from the picture plane $P\ P$, we have the vanishing point toward which the lines of the fence boards $q\ r$ converge, as shown at a in Fig. 5 (*c*), and if we lay off to the left of S a distance equal to the distance of the station point from the picture plane, we locate the point toward which the lines of the fence boards $q'\ r'$ converge, as shown at b in Fig. 5 (*c*).

* NOTE.—Fig. 5 is arranged so that the point x is, according to the scale, 5 feet 6 inches above the ground line, and on a level with the center of vision. The distance 5 feet 6 inches is here taken because it represents about the average height of the eye above the ground when a person is standing.

15. The student is advised to go over these simple explanations very carefully, to check each assertion and rule, in order to impress its truth upon his mind, and then to experiment for himself in rendering perspective drawings of simple objects, such as cubes, cylinders, prisms, etc., on this principle. As a matter of fact, this method is not satisfactory to lay off perspective drawings of objects that are seen at close range, but it illustrates a principle that, once properly understood, will enable the student to easily grasp the methods that follow, as well as to better understand methods of convenience in laying off measurements rapidly and simply according to geometrical rules.

GENERAL PRINCIPLES.

16. Proportions of Objects in the Plan.—From the preceding articles the student will see that the apparent proportions of various objects, as they appear in plan, are very easily obtained by drawing lines from their principal points to the station point of the observer, and by intersecting these lines at right angles to the line of direction with a line representing the *trace* of the picture plane. By **trace** is meant the imaginary line where the picture plane intersects the ground plane.

17. Appearance of Object in the Plan.—In order to impress this fact more clearly on the mind, we will now consider the perspective drawing and appearance of such objects as are expressed in plan only; in other words, the perspective of surfaces. In Fig. 6 (*a*), we have at *a b c d* a square distant from *S*, the station point, 6 inches. Lines drawn from each corner of the square *a b c d* are intercepted 1½ inches from *S* by the picture plane *PP*, thus making the distance from the station point to the picture plane one-fourth the distance from the station point to the square itself. The points where the lines from the corner of the square *a b c d* intercept the picture plane at *1*, *2*, *3*, *4* give the

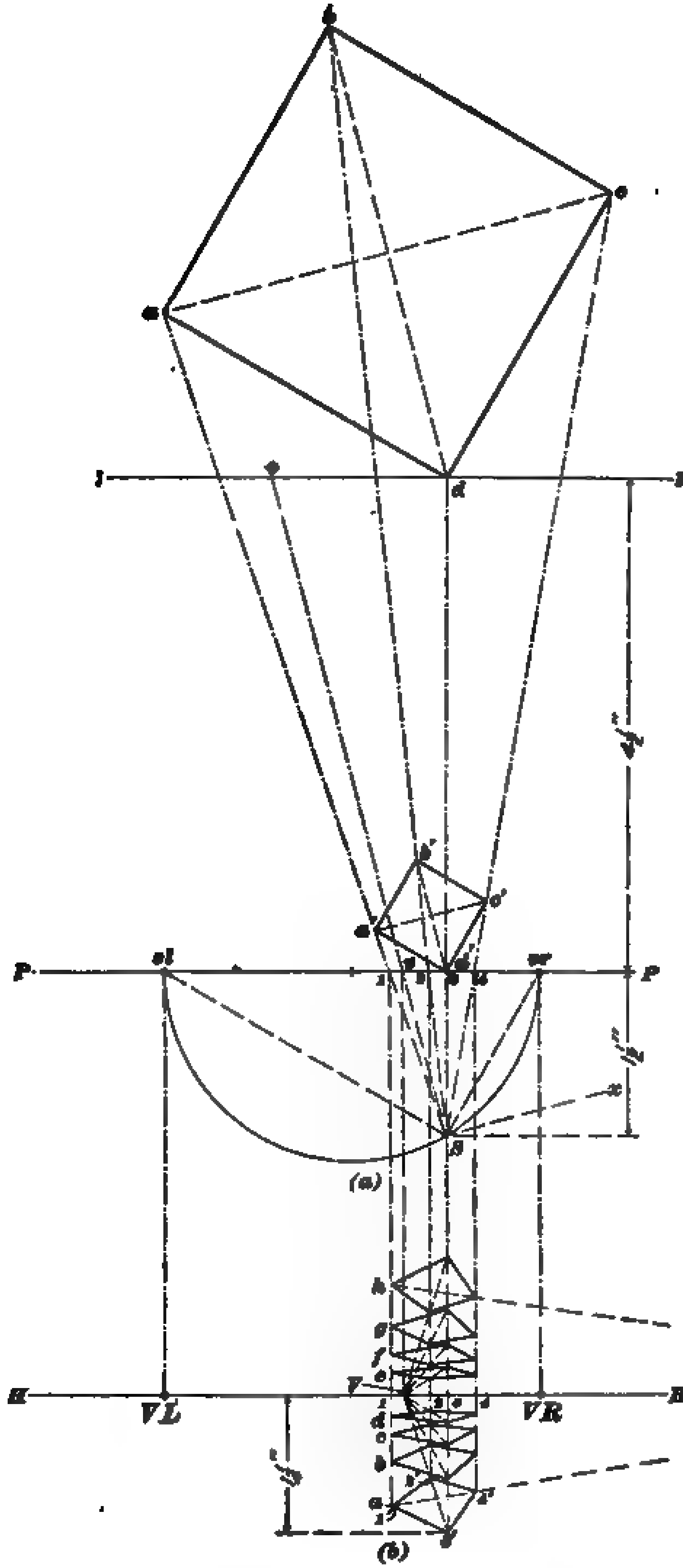


FIG. 6.

horizontal dimensions of the square *a b c d* as it appears in perspective.

18. Now, if, standing at *S*, we look in a direction parallel to the line *d c*, we will find the true vanishing point of that line to the right of *d* and somewhere on the line *l l* (which is parallel to the picture plane and touches the nearest corner of the square). The perspective of that vanishing point will be found where the same line from *S*, parallel to *d c*, intersects the picture plane, as at *v r*. In the same manner, if from *S* we look in a direction parallel to the side *d a* of the square, we will see the true vanishing point of the line *d a* on the line *l l*, and the perspective of this vanishing point will be where this line from *S* intersects the picture plane, as at *v l*.

19. It is therefore evident that if we look in the direction of the diagonal of the square *d b* we shall see the vanishing point of that diagonal, and all lines parallel to it at *v* on the line *l l*; where this line intersects the picture plane we have the perspective of this vanishing point, as shown at *v*. This is known as the vanishing point of 45°, inasmuch as it is the vanishing point of the diagonal of the square and is of vast importance in securing other measurements, as will be explained hereafter.

20. In the same manner, if we look from *S* in the direction parallel with *a c*—the other diagonal of the square—we will see the vanishing point of this diagonal somewhere on the line *l l*. This direction is shown by the dotted line *S x*, but its intersection with the picture plane is so remote that its vanishing point cannot be indicated in this illustration.

21. Reduction of Scale.—It should now be evident that if instead of drawing the square *a b c d* 3 inches on each side and 6 inches from the station point, we draw the square 1½ inches from the station point (which is one-quarter the former distance) and ¾ inch on each side (which is one-

quarter the former size), we have the same resulting measurements on the picture plane PP as before. Therefore, in drawing perspective views of objects that are inaccessible or too large to be expressed full size on paper, it is customary to draw their plans at a uniform scale and to decrease the distance from the station point to the object at a proportionate scale. The view of the square *a b c d* on the picture plane PP, as seen from the station point S, is precisely the same 6 inches distant from S, as the view of the square $a' b' c' d'$ 1½ inches from S, so long as the picture plane remains in the same position.

22. Now, below the original diagram, or if more convenient on a separate piece of paper, draw a horizon line HH and locate thereon VL and VR, as shown in Fig. 6 (*b*), and intersect the horizon with vertical lines drawn through points that correspond to *1*, *2*, *3*, and *4* of the picture plane; as said before, the horizontal limits of the square will then be in perspective. To render the perspective view of the square *a*, a line *3′–4′* is drawn toward VR representing the side $d' c'$ of the square, and a line *3′–1′*, is drawn toward the vanishing point VL, representing the side $d' a'$ of the square. *1′–2′* is then drawn toward VR, and *4′–2′* toward VL, representing, respectively, the sides $a' b'$ and $b' c'$ in the square above. Therefore, we have at *a*, a perspective view of the square shown in Fig. 6 (*a*) as it would appear 6 inches distant from S and 5 inches below the level of the eye or horizon at a scale of one-fourth the full size; or, in other words, the appearance of the square shown at $a' b' c' d'$ as it would appear 1½ inches from S and 1¼ inches below the level of the eye or horizon. In the same manner, each of the other perspective views of the square are drawn as shown at *b*, *c*, *d*, *e*, *f*, *g*, and *h* of Fig. 6 (*b*).

23. Effect of Position of Horizon.—It will be observed that as the perspective of the square is raised nearer the horizon the less of its surface is shown, until, when on the horizon line itself, none of it is shown, the edge of the square

being indicated simply by the line *1–4*. Above the horizon the under side of the surface comes into view, until at *h*, the

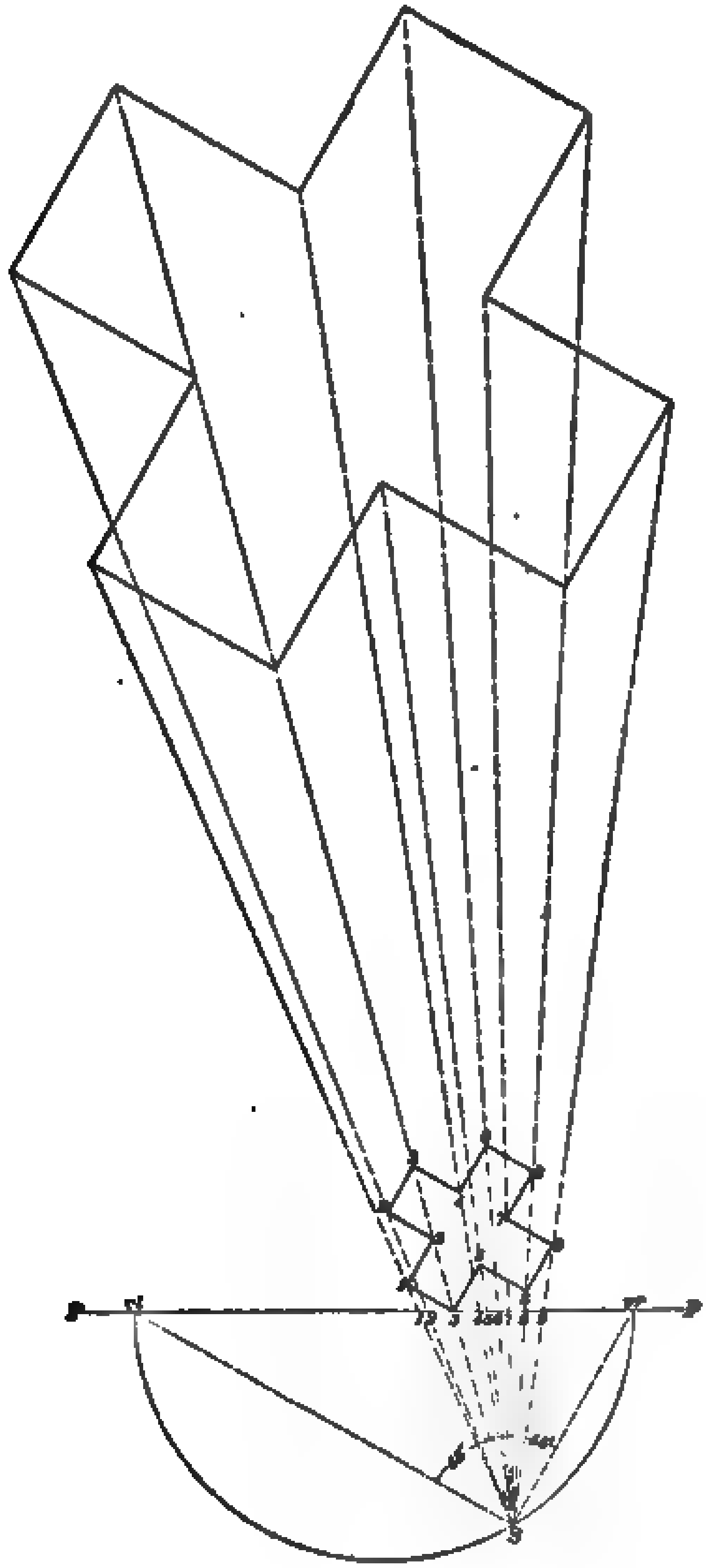


Fig. 7.

view of the under side appears in the same area as the view

of the upper side at *a*, *k* being the same distance above the horizon that *a* is below.

24. The dotted line drawn from the corner *3'* through the corner *2'* is the same as the diagonal of the square drawn from *d* to *b* in Fig. 6 (*a*), and similar diagonals drawn through the other perspectives will all meet on the horizon line in the point *V*, which is the vanishing point of 45°. In a like manner, the diagonal *1'–4'* of the perspective of the square *a*, if carried sufficiently far to the right, will intersect the horizon line at precisely the same distance to the right of *V* that the line *S x* will intersect the picture plane *PP*, in Fig. 6 (*a*), to the right of the point *v*.

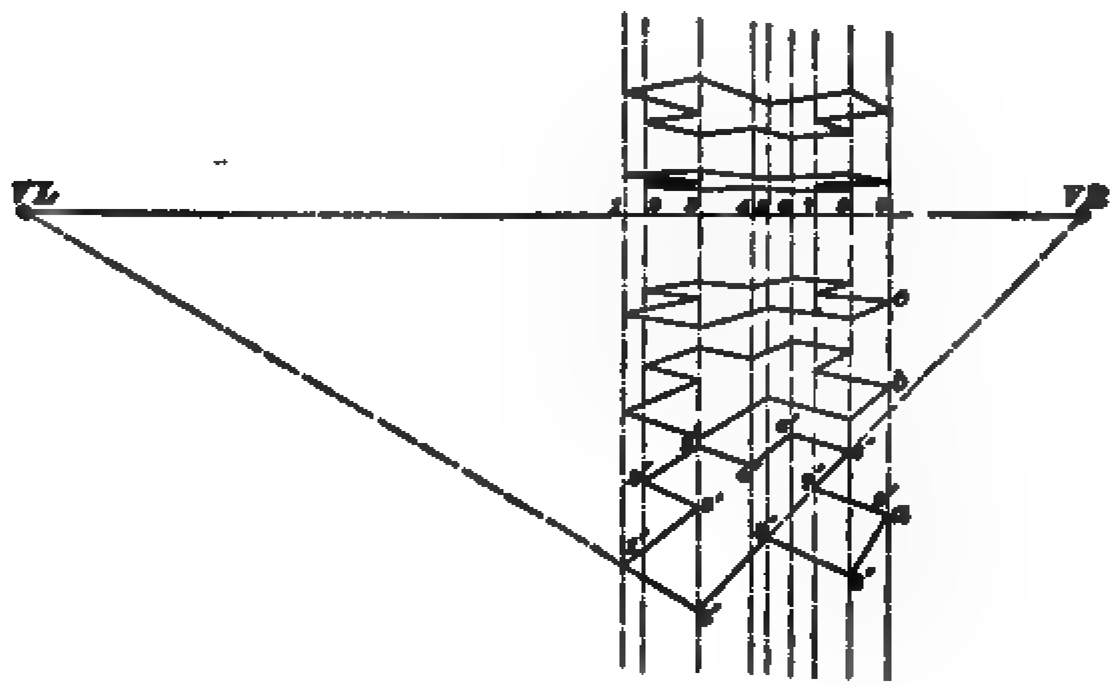


FIG. 8.

25. Fig. 7 is precisely the same in principle as Fig. 6, except that the figure of the Greek cross is more complicated. In the plan, each arm of the cross measures 1½ inches and is situated 6 inches from the station point *S*, as in the previous example, while the picture plane remains 1½ inches from *S*. The smaller cross, drawn one-fourth the size of the other one, is in contact with the picture plane at point *3*, and lines drawn from its several angles, toward *S*, intersect the picture plane at points *1*, *2*, *3*, *4*, etc. A line locating

the vanishing point of 45° passes through the corners as indicated, and lines drawn from S parallel to the sides of the cross locate the vanishing points $v\,l$ and $v\,r$.

26. In Fig. 8, VL and VR have been located on the horizon line the same distance apart as in Fig. 7, and through points corresponding with the intersections on the picture plane of Fig. 7, *1*, *2*, *3*, *4*, etc., vertical lines have been drawn that limit the horizontal dimensions of each arm of the cross. A comparison of the plan of the cross in Fig. 7 with the perspective views of the cross in Fig. 8 will show that in the lower perspective *a*, the line *3′–1′* toward the vanishing point VR corresponds with the side of the arm *3–1* of the cross in Fig. 7, and that *3′–5′*, *5′–8′*, *8′–9′*, etc. correspond with similar details in the plan of the cross in Fig. 7.

These five perspective views possess the same characteristics, of course, as they approach the horizon, as did the perspective views of the squares in Fig. 6 (*b*), each one representing that surface on a different level, as viewed from the same station point.

27. Fig. 9 is a similar arrangement, on a larger scale, of the two perspectives of the cross marked *b* and *c* in Fig. 8. The vertical lines marking the projected dimensions of the perspective are numbered as in the previous figure, for convenience, and the two crosses bear the same relation to each other and to the horizon as in Fig. 8, and appear, in this case, somewhat as if suspended from the horizon by a series of chains. If we assume that these two surfaces, crucial in form, are the bounding surfaces of the top and bottom of a solid, we can, by filling in the intermediate lines, produce a perspective view of this solid, as shown in Fig. 10.

28. Here the line *a b* is equal in length to the space *a b* in Fig. 9, making the thickness of the cross equal to the length of each of its arms. The upper surface is the only one seen here in full, inasmuch as the solid portion of the cross hides the lower surface and we see nothing but its out-

line in front. The line *a b* is drawn full size and equal to *a b* of Fig. 9, because it is in contact with the picture plane, as will be explained hereafter, and the student's attention is

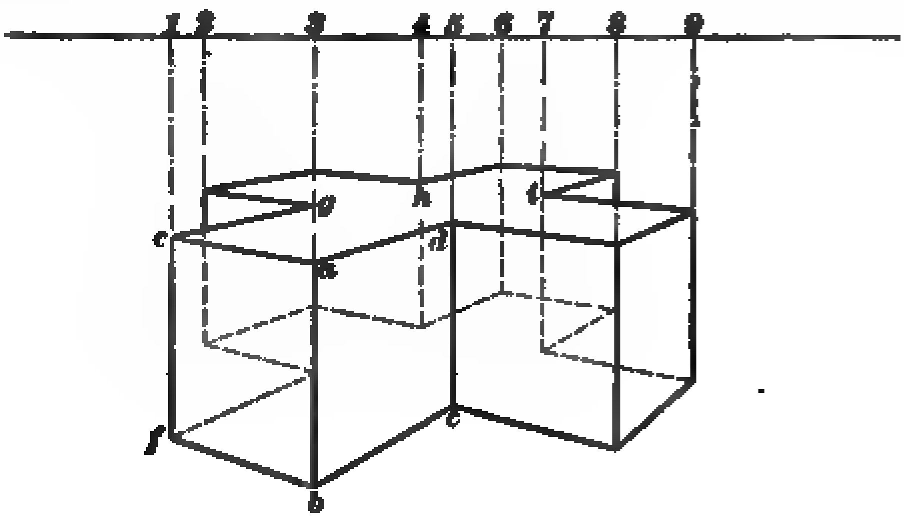


FIG. 10.

now particularly called to the fact that the solid cross whose area in plan is shown in Fig. 9 is represented in perspective in Fig. 10 with its proper thickness *a b* and its perspective dimensions *a d*, *a e*, etc. precisely laid out.

29. The rectangles *a b c d* and *a b f e* are vertical surfaces bounding two sides of one arm of the cross and illustrating, as said before, the fact that all surfaces are bounded by lines and all solids are bounded by surfaces, the perspectives of which lines and surfaces, properly arranged, will produce a perspective view of the solid. The interior angles of the crucial form at *d*, *g*, *h*, and *i* will form a square on the upper surface in the center, if connected; and without further dimension lines we can erect above and below this form a cubical block causing the figure to assume the appearance shown in Fig. 11, where the corner *d k* is raised above the crucial form a distance equal, in perspective, to *a b*, and below the form from *c* to *l* a similar distance. Vanishing lines drawn to points *VL* and *VR* determine the outlines of the top and bottom of these added cubes, and it will be observed that the top lines bounding the upper cube coincide with the horizon line and show nothing of the upper surface.

As the line *a b* is in contact with the picture plane, this distance is again laid out from *b* to *l'* (also in the picture plane) in order to project its perspective equivalent *c l*, as shown by the dotted line *b l'*; and the line from *l'* toward the vanishing point *V R* intersects the vertical line marking this corner, under *5*, and establishing the depth of the cube below the general figure.

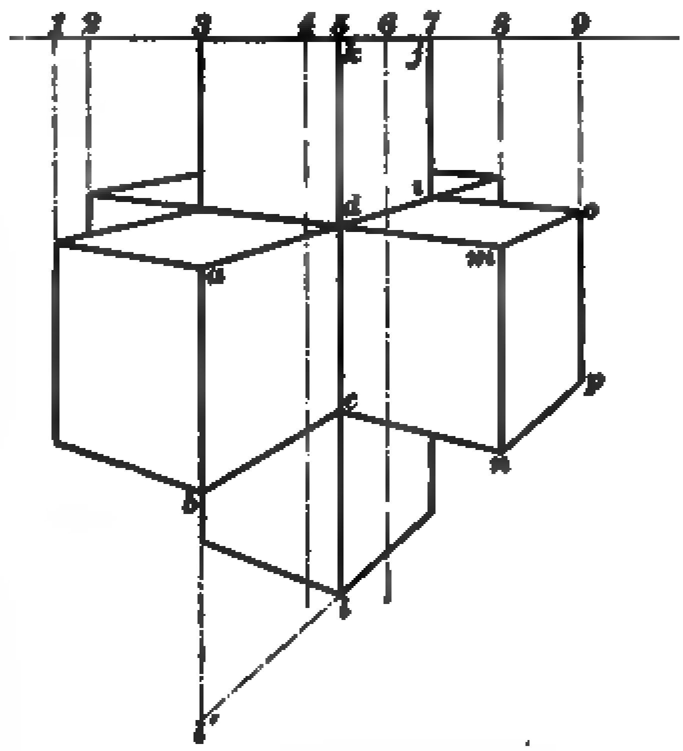


FIG. 11.

30. It is very evident that this, in reality, is the perspective view of a figure composed of seven cubes—one in the heart of the whole solid, which does not show, and the others, one on each of the six faces of the first one. If we should remove the cube *d m o p n* and its mate on the opposite side, we should, undoubtedly, expose the interior cube beyond *a b c d* and under *k d i j*, thereby producing a figure similar to that shown in Fig. 12, where the dotted lines indicate the face of the central cube and also the surface from which one of the cubes was removed. The result of this is a perspective of a solid

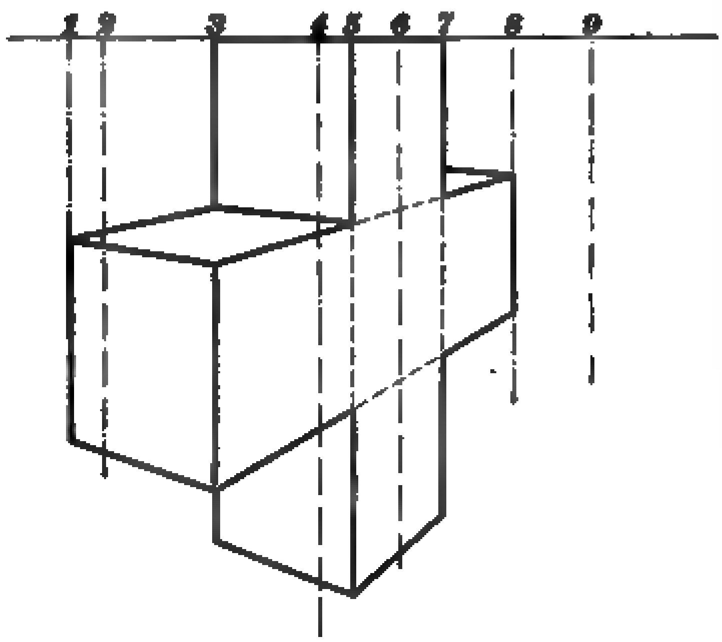


FIG. 12.

similar to that shown in Fig. 10 but in another position, thus illustrating the constancy of perspective lines toward given vanishing points and the fact that the proper arrangement of perspective views of surfaces will present the perspective views of solids.

31. Therefore, it should always be borne in mind when making a perspective drawing, that each surface is to be considered separately and a perspective view made of that surface by considering each of its lines separately and making a perspective view of each line. The most complicated perspective thus resolves itself down to very simple details.

GEOMETRICAL PRINCIPLES.

PLANES AND TRACES.

32. Traces of Planes.—All lines in a perspective drawing may be considered as being located in various planes, and the intersection of these planes with the picture plane produces an imaginary line that we consider as the trace of

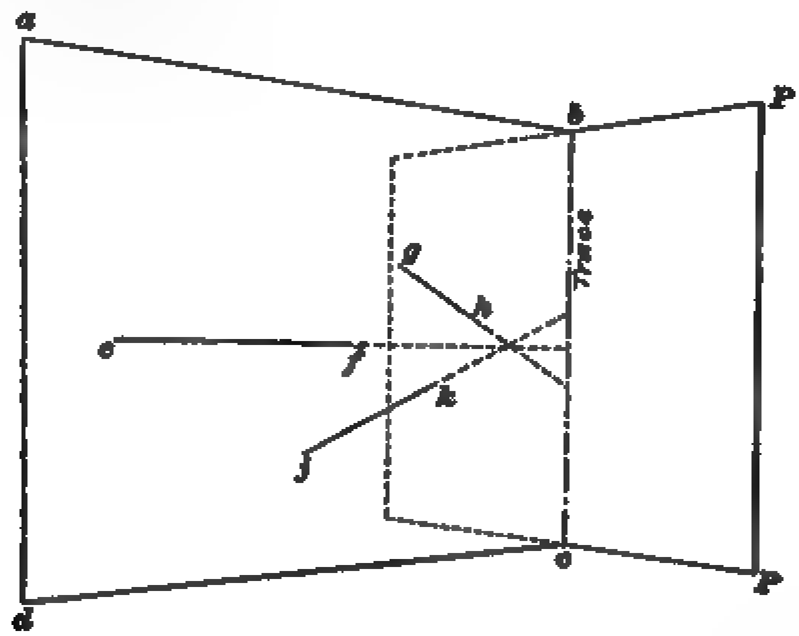


FIG. 12.

that plane. Now, all lines lying in any given plane have their vanishing points somewhere in the trace of that plane.

For instance, in Fig. 13, we have a perpendicular plane *a b c d* that is also perpendicular to the picture plane *P P* and intersects it on the line *b c*; *b c* is, therefore, the trace of the plane *a b c d*. All lines lying in the plane *a b c d* will, therefore, have their vanishing points in the trace *b c*, as is shown by the lines *e f*, *g h*, and *j k*, all of which lie in the plane *a b c d* and if extended to the picture plane *P P* have their vanishing point in the trace *b c*.

33. Vanishing Points in Traces.—In the same manner we have, in Fig. 14, a horizontal plane perpendicular to the picture plane and all lines in that horizontal plane have their vanishing points in the trace *b c*. We therefore assume that there is an infinite number of planes inclined at all angles to

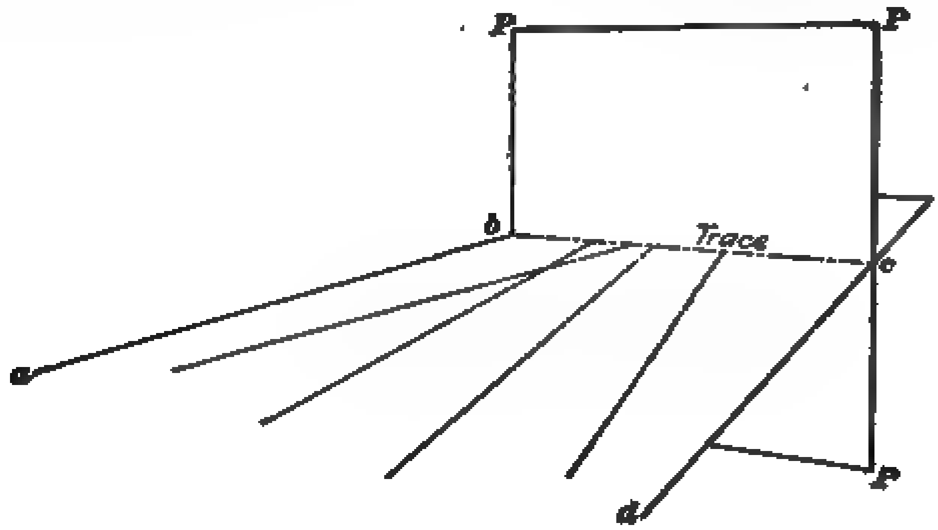


FIG. 14.

the picture plane and that their traces, or intersections with the picture plane, form imaginary lines whereon we can find the vanishing points of all lines within each plane. Therefore, in locating the vanishing point of one or more lines it is first necessary for us to determine in what plane those lines lie and then to locate the trace of that plane on the picture plane.

34. Systems and Elements.— All parallel planes vanish in one trace in the same manner that all parallel lines vanish in one point. A group of parallel lines or planes is known as a **system** of lines or planes, and any one plane or line is known as an element of the system. To find

the perspective of the trace of any plane, or any system of planes, pass through the station point S an element of the system, and the line where it intersects the picture plane will be the perspective of the trace of that plane. In the same way, the perspective of the vanishing point of any line, or system of lines, may be found by passing through the station point S an element of that system, and the place where it pierces the picture plane will be the perspective of the vanishing point of that line.

35. Inclined Planes.—This phenomenon of lines lying in a given plane is illustrated, somewhat, in the case of the coal box shown in Fig. 15. Here is a vertical plane *a b c d*, the bounding lines *a b* and *d c* of which and the horizontal lines

FIG. 15.

lying between them vanish toward the right, or, in other words, at VR, while the horizontal lines of the vertical plane *a d e f* vanish toward the left, or, in other words, at VL. These lines are expressed on the sides of the coal box by the

boards of which it is built, while the lid, which is tilted upwards, forms a third plane *f g h k* that is neither vertical nor horizontal but whose bounding sides *g h* and *f k* and the horizontal lines lying between them vanish in *V R*.

36. Lines of Intersection.—Another plane may be considered to exist at another inclination, as shown at *f k b a*, whose bounding lines *f k* and *a b* vanish in *V R*. *a b* and *f k* are, therefore, each located in two different planes, *a b* being located in the plane *a b c d* and also in the plane *f k b a*, and *f k* being located in the plane representing the lid of the box and in the plane to which that lid closes when shut. It is evident, therefore, that the lines *f k* and *a b* are the lines of the intersection of two planes, and from this fact we draw the following rule:

Rule VI.—*The line of intersection of any two planes has its vanishing point in the intersection of the traces of those planes.*

This rule is of vast importance in locating vanishing points of such inclined lines as are not readily projected on the picture plane.

37. Plane of Measures.—If a portion of the object represented in perspective is in contact with a vertical plane, all measurements on the portion of the object in contact will be exactly proportional to the actual measurements of the object itself, and may be there laid off.

38. In Fig. 16, we have a vertical plane *P P* intersected by a horizontal plane *G G*. Resting on this horizontal plane, and in contact with the opposite side of the vertical plane, stands a cube, as shown, the corner *a b* of the cube being in contact with the vertical plane; therefore, the perspective measurements of that line can be laid off in any proportion to the actual measurements on the cube. It is usual in perspective drawings to make this proportion $\frac{1}{24}$, $\frac{1}{48}$, or $\frac{1}{96}$, or, in other words, at a scale of $\frac{1}{2}$, $\frac{1}{4}$, or $\frac{1}{8}$ of an inch to the foot.

The same scale can also be used to lay out the side *defh* of the cube to the left, one whole face of which is in contact with the vertical plane *P P*. The plane *G G* corresponds with the ground plane of the picture and the line *g g*.

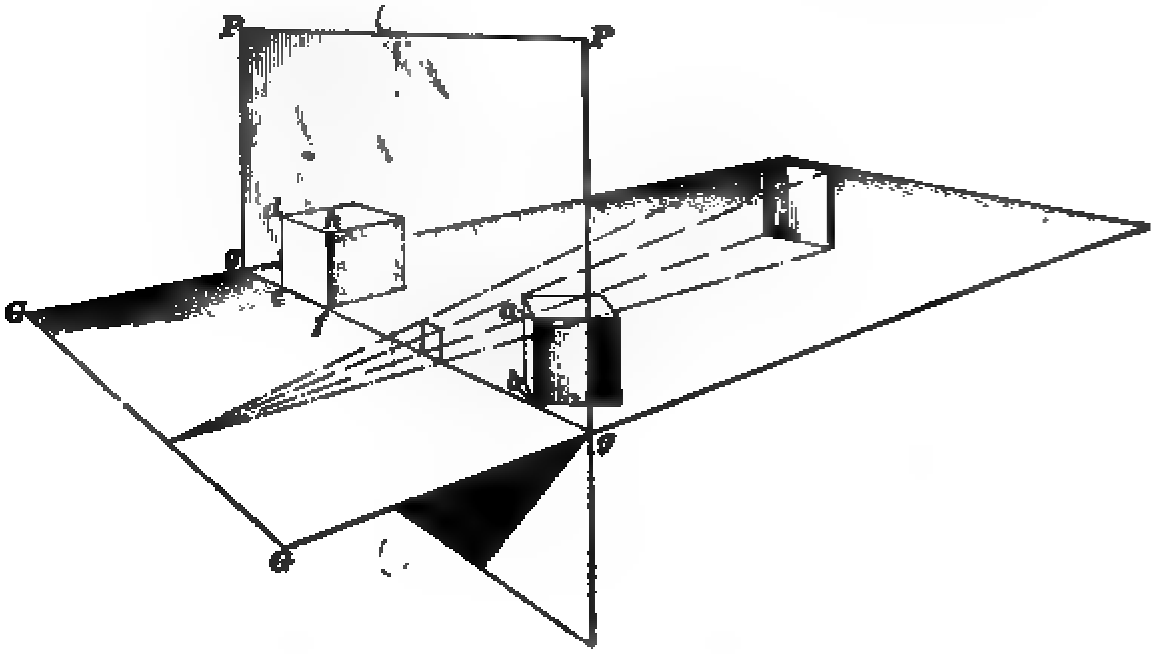


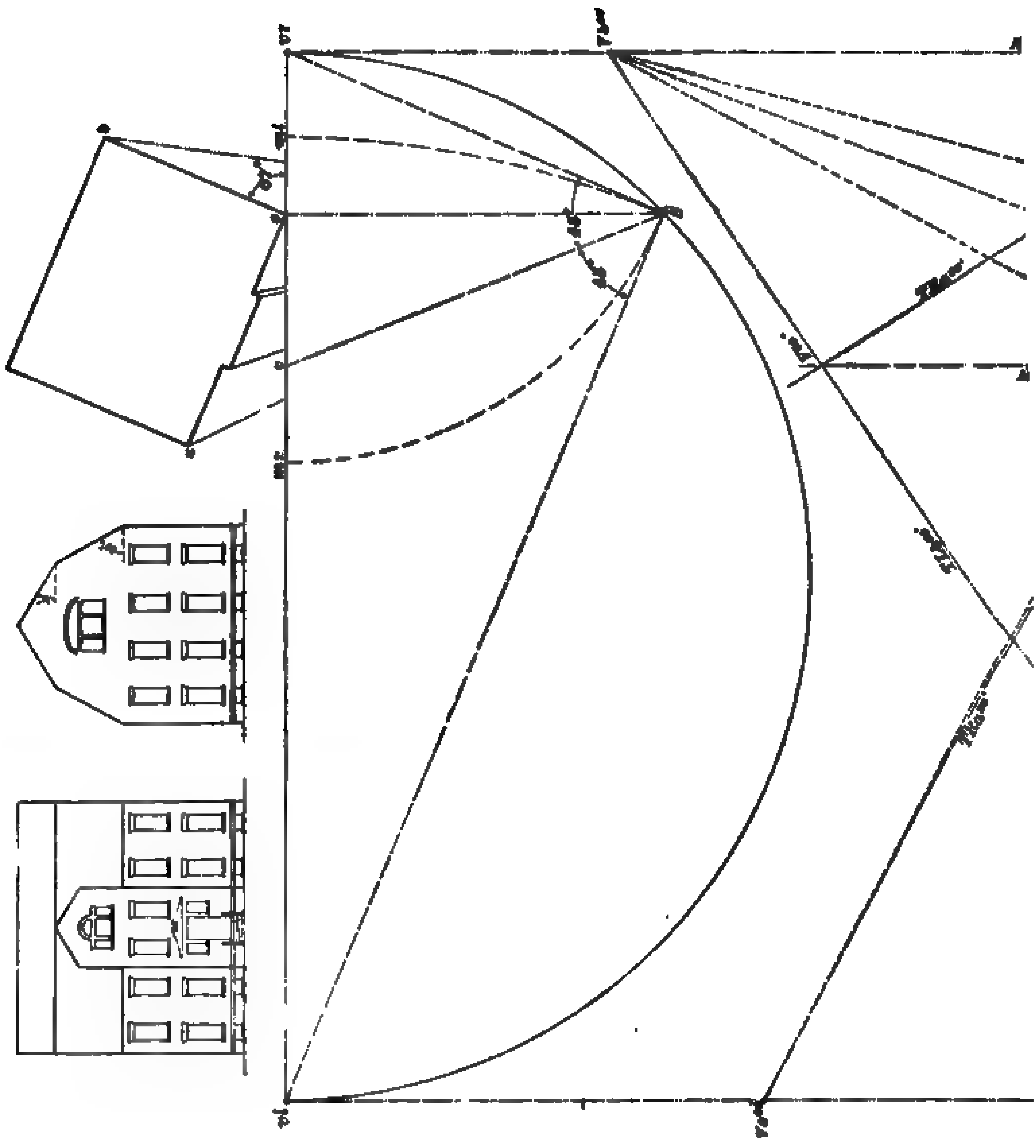
FIG. 14

Where the plane *P P* and the plane *G G* intersect is the ground line of the picture and can be used to lay off measurements horizontally. It is evident from this that all lines in the same plane are in the same proportion to each other as the actual lines in the object itself

39. A vertical plane, as *P P*, in contact with the object to be drawn is called a **plane of measures**; hence:

Rule VII.—*All lines in a plane of measures have their perspectives drawn to the same scale.*

40. The center of the plane of measures corresponds, in the picture, to *C*, the center of the picture, and any other point may be located in the picture by laying off its distance with a scale in the desired direction, as the plane of measures is parallel to, and coincides with, the picture plane itself.



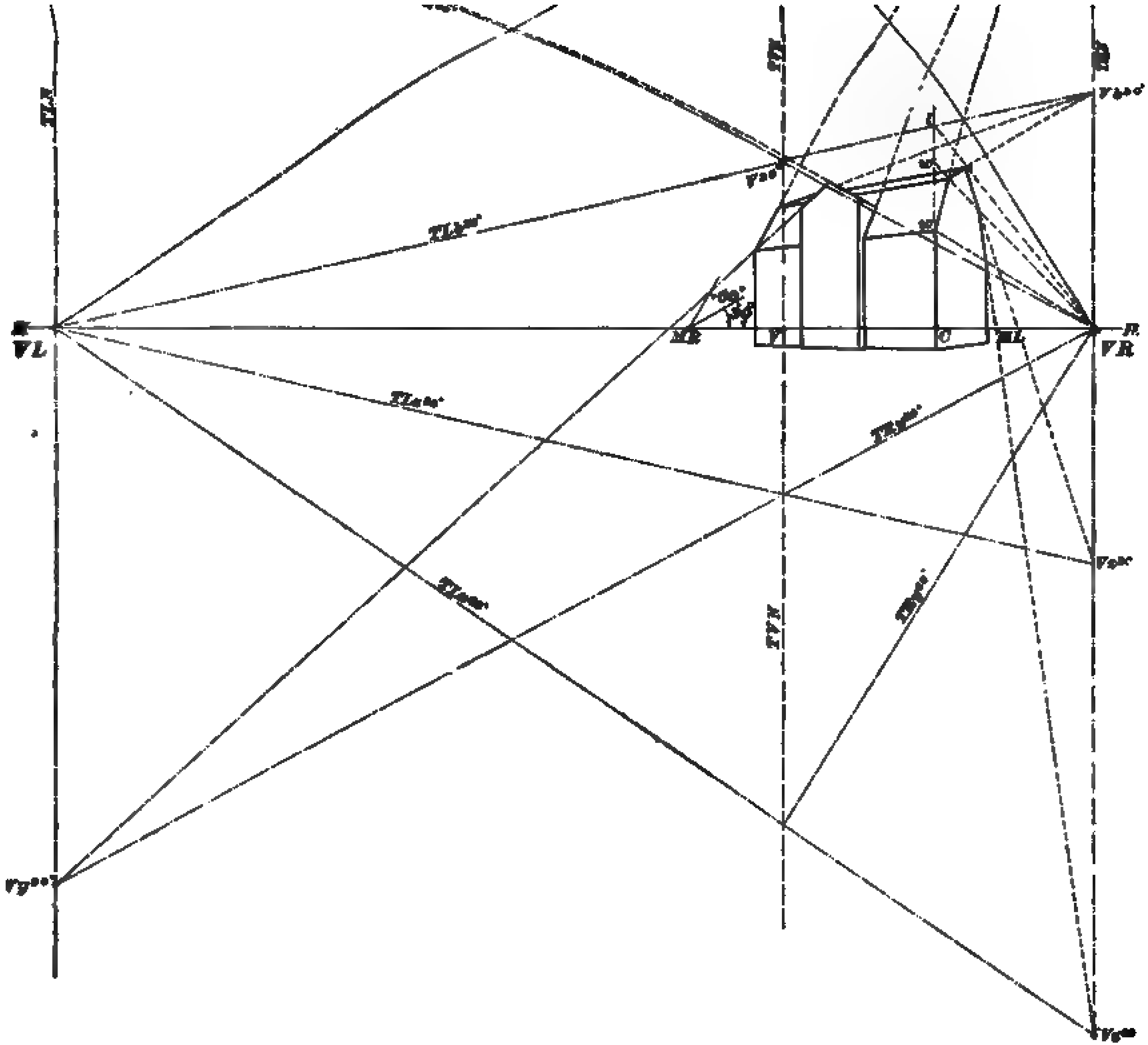


FIG. 17.

DEMONSTRATION OF PRINCIPLES.

41. Location of Principal Vanishing Points.—It is now necessary to put into practice what has been learned concerning the determination of the magnitude and direction of perspective lines in a drawing. Fig. 17 shows a plan of a small house at *a b c*. The spectator is assumed to be at *S* and the sides of the house are inclined to the picture plane at angles of 23° and 67°. Lines drawn from *S* parallel to the sides of the house will intersect the picture plane at *v l* and *v r*, thereby establishing the vanishing points of the respective sides, while directly in front of the spectator is the center *c* of the picture. As the two sides of the house *a c* and *b c* meet in a right angle at *c*, the triangle below, at *v r*–*S*–*v l*, is a right-angle triangle; and according to Case II, Problem 2 of *Geometrical Drawing*, its three angles lie in the circumference of a semicircle of which *v l* and *v r* mark the extremities of the diameter.

Vertical lines may now be drawn through *v l* and *v r*, and as these lines represent the traces of vertical planes, they will contain the vanishing points of all lines parallel to the sides of the house *a c* and *b c* whether those lines are horizontal or inclined; in other words, the lines of the gable on the end of the house *b c* will have their vanishing points somewhere on the vertical line through *v r* and the lines of the gable on the side of the house *a c* will have their vanishing points somewhere in the trace of the vertical plane through *v l*. In the same manner, any other vanishing points and the traces containing them may be established. All horizontal lines parallel to the sides of the house *a c* and *b c* will have, of course, their vanishing points at the intersection of the horizon and the vertical traces through *v l* and *v r*. Inclined lines, as said before, will have their vanishing points above or below the horizon, according to circumstances.

42. Location of Minor Vanishing Points.—According to the elevations that are shown to the left of the plan,

we find that the angle of the roof of the house is 60° for the lower slope, and 30° for the upper slope. It is now assumed that if the spectator standing at S were to look in the direction of vr and upwards at an angle of 60°, he would see the vanishing points of the lines parallel to the lower slope of the roof; and if he were to look upwards and toward vr at an angle of 30°, he would see the vanishing points of the lines parallel with the upper slope of the roof. But as the ends of these slopes are in the same plane as the end of the house bc, their vanishing points will be somewhere in the trace of the plane through vr.

43. Let us refer for a moment to Fig. 18, where we have a perspective view of our drawing board with these imaginary lines, not flat on the paper, but arranged apparently in their true relations to the surface of the board. Here we have the horizon line extending between VL and VR, while our station point is at S in the circumference of a semicircle with VL and VR at the extremities of its diameter. From S we have the line S–VR corresponding to the line S–vr in the plan of Fig. 17, and the line S–VL corresponding to the line S–vl in Fig. 17; but the line from S to Vb is inclined at an angle of 60° with the line S–VR; that is to say, that the triangle S–VR–Vb has its angle at $S = 60°$, and the line from S to Va is inclined at an angle of 30° with the line S–VL; thus making the points Vb and Va the vanishing points of all lines inclined upwards at an angle of 30° and contained in the system of vertical planes passing through S–VL and S–VR.

44. Measuring Points.—It is evident that if we revolve this triangle, with the side VR–Vb as an axis, until the point S is brought against the horizon line at MR, that we have marked a point on the horizon line from which we can lay off an angle of 60° and still establish the point Vb. In the same manner we can revolve the triangle S–VL–Va around the side VL–Va as an axis, the point S will locate ML a point wherefrom we can lay off, to the left, an angle of 30°, and

establish the point *Va*. These points *MR* and *ML* are termed **measuring points.**

45. Fixed Traces and Points.—Any series of lines that are not parallel to one another but that lie in the same

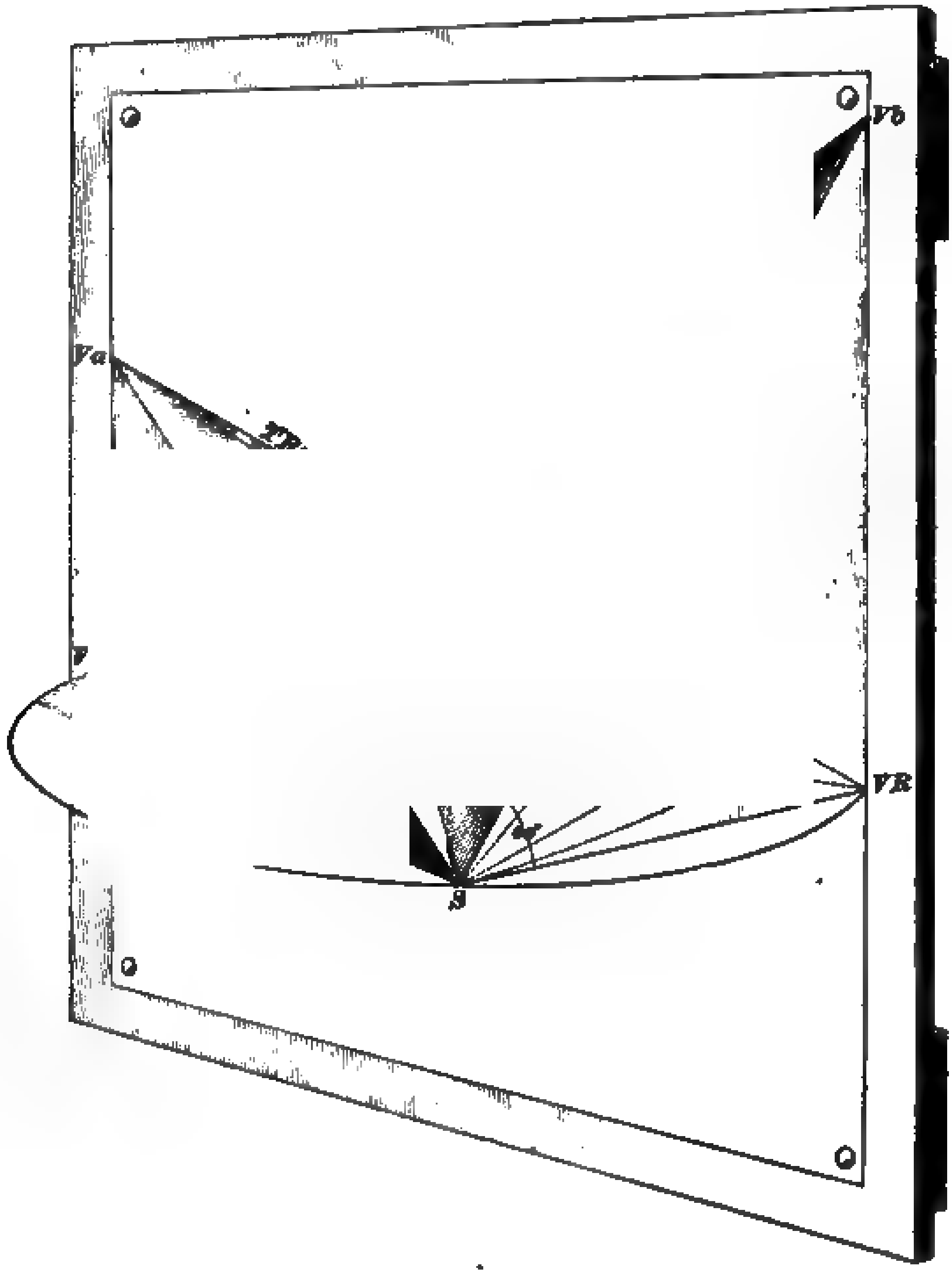


FIG. 18.

plane, will have their vanishing points in the trace of that plane, as shown by the lines from *S* toward *Vb* and toward

VR, and parallel lines in the same plane will have the same vanishing point in the trace of that plane. The trace of a horizontal plane is called the **horizon,** and the horizon contains the vanishing points of all lines that are parallel to that plane whether they are parallel to one another or not. A vertical plane that is at right angles to the horizon has its trace through a point in the horizon directly in front of the spectator; the point is called **the center of the picture** and is marked C.

In Fig. 17, the horizon HH has been drawn at any convenient place on the paper and the points VL and VR have been located thereon the same distance apart as vl and vr are shown above. MR, V, C, and ML are then located on this horizon line in positions corresponding with similar points in the plan above. From MR, at an angle of 30° with the horizon, a line is drawn upwards and to the right, thus establishing the point Vb^{30}; and from MR, at an angle of 60°, upwards and to the right, a line is drawn establishing the point Vb^{60}. Similarly, lines are drawn upwards and to the left of ML establishing the points Va^{30} and Va^{60}, and below the horizon also the points Vx^{30} and Vy^{30} are located by drawing from MR and ML lines at angles of 30° downwards and to the right and left, respectively.

In doing this, we have simply represented on the drawing board the appearance that is shown above the horizon line in Fig. 18 after the circular plan VL–S–VR is removed. Any other vanishing points that may be desired may be similarly located, first, by looking from S in a direction parallel to the line, and locating the point wherein that line of sight pierces the picture plane. All lines at an angle of 45° with S–vl and S–vr will vanish at v if they are horizontal lines, but if inclined upwards or downwards they will vanish somewhere in the trace of a perpendicular plane passing through V. All lines perpendicular to the picture plane will naturally have their vanishing points in the center of vision at C, as a line drawn from S perpendicular to the picture plane intersects the picture plane at c.

46. Method of Procedure.—In making a sketch in perspective, the two vanishing points VL and VR are first located as far apart as is convenient. On the circumference of a semicircle struck between them, a station point is located in such a position that lines from the station point to each of the vanishing points will be parallel to the sides of the object to be drawn. This is shown in Fig. 17, where $v\,l$ and $v\,r$ are first located on a line that just touches the corner c of the house, as shown. The semicircle $v\,l$–S–$v\,r$ is then drawn, and the lines $v\,l$–S and $v\,r$–S are drawn parallel to the sides $a\,c$ and $b\,c$ of the house. A line at right angles with the horizon line and passing through S will then give the center of the picture at c, and a line at 45° with S–$v\,l$ or S–$v\,r$ will have its vanishing point at v. Bearing these facts in mind, all other vanishing points can be easily determined.

47. Notation of Vanishing Points.—Throughout this text certain constantly recurring points, traces, and planes will be designated uniformly by the following set of symbols, which the student should study carefully, in order that he may thoroughly understand the significance of each. V will always signify a vanishing point in the elevation of the picture plane, as shown in the lower part of Fig. 17, and v will indicate a vanishing point in the plan of the picture plane, as shown in the upper part of Fig. 17. (The relation between the plan and elevation is shown in Fig. 18.) These vanishing points will generally be qualified by another letter, to indicate which vanishing point is referred to, thus establishing, uniformly, the following vanishing points:

VR, the vanishing point of horizontal lines toward the *right*.

VL, the vanishing point of horizontal lines toward the *left*.

V, the vanishing point of 45°.

Va, the vanishing point of lines inclined *upwards* to the *left*.

Vb, the vanishing point of lines inclined *upwards* to the *right*.

Vy, the vanishing point of lines inclined *downwards* to the *left.*

Vz, the vanishing point of lines inclined *downwards* to the *right.*

It will be seen that in the elevation, the vanishing points on the horizon are expressed entirely in capital letters, that vanishing points above the horizon are expressed by the addition of the lower-case letters a and b, and any additional vanishing points that may be required hereafter will be designated by the first letters of the alphabet when above the horizon, and by the last letters of the alphabet when below the horizon.

48. Notation of Planes and Traces.—Planes and their traces will be similarly indicated, the letter T always being used to express the trace of some plane, and it will be followed by two letters designating two points through which the plane passes, thus qualifying it. Thus, TLb will be the trace of a plane through L and b, L in this case being used for an abbreviation for VL, and b as an abbreviation for Vb.

TLb is the trace of a plane through L and b (that is, through VL and Vb) inclined upwards and toward the *right.*

TRa is the trace of a plane through R and a (that is, VR and Va) inclined upwards and to the *left.*

TLz is the trace of a plane inclined downwards and to the *right.*

TRy is the trace of a plane inclined downwards and to the *left.*

Vertical planes—those running to the zenith or nadir—will always be designated by the letter N. Therefore,

TLN will be the trace of a plane toward the *left* and to the nadir.

TRN will be the trace of a plane toward the *right* and to the nadir.

49. In order that the student may get these more clearly in his mind, he should associate all of them with the station

point and remember that to the left always means to the left from the station point. $L\ N$ is, therefore, a vertical plane passing through S and inclined toward the left, so as to pass also through $V L$. The trace of this plane $T\ L\ N$ will, therefore, contain all the vanishing points of all lines lying in this plane or any other plane parallel to it. The plane $R\ N$ is a vertical plane passing through the station point S and the point $V R$, and its trace $T\ R\ N$ will contain $V R$ the vanishing point of all horizontal lines in this plane, as well as other vanishing points, above or below the horizon, of any inclined lines in the surface of this plane or of any plane parallel to it.

50. The inclined lines $T\ R\ a$ and $T\ L\ b$ are not quite so easy to comprehend, but they are the traces of planes that pass through S, in the same manner as the previous ones, but instead of being vertical, are inclined and pass also through some point a or b above the horizon, thereby making a diagonal trace on the picture plane. The surface of one of these planes is indicated, Fig. 18, by the triangle S–$V L$–$V b$, and the other one by S–$V R$–$V a$.

51. The student should now take a sheet of paper and draw Fig. 19 entirely, according to the foregoing description and following explanation, being careful not to copy the illustration but to demonstrate for himself each detail as it is set forth. Dimensions are, therefore, of no importance but the distance between the vanishing points $V L$ and $V R$ should not be less than 12 inches.

Having drawn a line, representing the picture plane between the two vanishing points $v\ l$ and $v\ r$ and having struck a semicircle on the center of this line, as shown at $v\ l$–S–$v\ r$, Fig. 17, draw the line $S c$, making the center of vision and the nearest corner of the house coincident. $S v$, being drawn at an angle of 45° with S–$v\ r$ and S–$v\ l$, gives us the location of the vanishing point of 45°. With the radius S–$v\ r$, lay off from $v\ r$, to the left, the point $m\ r$, as explained in Fig. 18, and with the radius S–$v\ l$ lay off to the

right of *v l*, the point *m l*; *m l* and *m r* are called **measuring points**, inasmuch as they are used to measure certain perspective dimensions and to locate certain vanishing points, as explained hereafter. In this plan, the line *S–v l* can be considered as the trace of a plane passing through *S* and *v l*, and each of the other lines *S–v r* and *S v* can be considered as traces of other planes.

Referring to the details below this plan of our horizon and its subdivisions, we have at *V L* and *V R* the horizon of our picture with the center of vision *C* and the 45° vanishing point at *V*. These, as well as the points *M L* and *M R*, are located exactly beneath points indicated by similar lowercase letters in the plan above. Through *V L* and *V R* are drawn vertical lines representing the traces of the planes *L N* and *R N*, that is, of vertical planes that make vertical traces through the picture plane, as shown, and are inclined toward the right and the left, so as to intersect the ground plane on the dotted lines shown in the plan above at *S–v r* and *S–v l*.

From *M R*, an angle of 60° is laid off, as that is the angle of the lower pitch of the roof of the house. Where the line marking this angle intersects with *T R N* we mark the vanishing point Vb^{60}, and below this, where an angle of 30° *M R* intersects *T R N*, we mark Vb^{30}; that is, these are the two points where all lines passing through *S* toward *v r* and upwards at an angle of 60° or 30°, and all lines parallel to them, will vanish.

From *M L* we lay off, toward the left, angles of 30° and 60°, locating on *T L N* the points Va^{30} and Va^{60}—the vanishing points of lines passing through *S* toward *V L* but upwards at an angle of 30° or 60°. A line drawn through *V L* to Vb^{30} will then represent the trace of a plane inclined to the *left* from *S*, so as to pass through *V L*, and upwards to the right, so as to pass through Vb^{30}; and a line drawn from *V R* to Va^{30} will represent the trace of a plane passing through *S* and inclined to the *right* through *V R*, but inclined upwards toward the left so as to pass through Va^{30}.

As a matter of fact, these are the planes that include the surface shown in the 30° slopes of the roof, and the intersection of these planes at V^{30} will locate the vanishing point of the intersection of these roof slopes, or in other words, the lines of the hips and the valleys, as shown in Fig. 18 by the line Sc. The two planes VL–Vb–S and Va–VR–S (Fig. 18) have for their traces the lines $TR\,a$ and $TL\,b$, and for their line of intersection the line Sc; therefore, the vanishing point of their line of intersection will be at the intersection of their traces, as at c.

A vertical plane passing through this vanishing point V^{30} will give the trace $T\,V\,N$, that is, the trace of a plane passing through V (the vanishing point of 45°) and to the nadir.

52. In identifying the traces of these planes, it should always be borne in mind that they are assumed to pass through the station point, though they represent equally well the traces of any other planes that are parallel to the one indicated through the station point. For, in the same manner that all parallel lines vanish in a *point*, it is equally true that all parallel planes vanish in a *line* or *trace*. To prevent confusion in this and all of the subsequent diagrams, the traces of planes on the picture plane will be indicated by a broken line consisting of a dash and two dots, while the lines of direction will be dotted. Measuring lines will be composed of dashes only.

53. It will now be seen that the lower slope of the roof of the house is a plane, two of whose lines vanish in VL and whose end lines vanish in Vb^{30}. The horizontal lines of the upper slope vanish also in VL, while the ends vanish at Vb^{30}. The lower slope therefore lies in a plane whose trace is marked $TL\,b^{30}$, and whose upper slope lies in a plane whose trace is marked $TL\,b^{30}$. The other sides of the roof, only the right-hand end lines of which are seen, have their ends vanishing below the horizon—in Vz^{30} and Vz^{30}, these points being located in precisely the same manner as were similar points above the horizon.

54. Any line on the surface of the lower roof slope in the perspective of this house will have its vanishing point somewhere on the trace of the plane $T L b^{60}$, and any line on the surface of the upper slope of the house will have its vanishing point in the trace of the plane $T L b^{30}$. In the same manner, any line in the upper or lower slope of this roof on the opposite side of the building will have its vanishing point in one of the traces $T L s^{30}$ or $T L s^{60}$ below the horizon, as shown.

45° PERSPECTIVE.

55. Position of Picture Plane.—In Fig. 19 there is no change in the position of either the house or the spectator, but the picture plane is revolved about the corner of the house c, so that it makes an angle of 45° with the sides instead of 67°, and the spectator at S has his center of vision c' to the left of the corner of the house instead of coincident with it, as was the case in Fig. 17. The previous position of the picture plane is shown by the broken line $e f$ in Fig. 19, and the change to its present position, as shown by $P P$, introduces some peculiar characteristics that are of great advantage.

56. Advantages of the 45° Angle.—The center of the picture c' and v, the vanishing point of 45°, coincide in this case, and the principal lines from S to $v l$ and $v r$ make an angle of 45° with the picture plane. This very clearly illustrates the point that—the position of the spectator and of the object having been determined—it makes no difference whatever how the picture plane is placed, inasmuch as the view of the object remains the same and the introduction of the picture plane is simply a means of acquiring points of measurement in the object by which it can be reproduced in appearance; and as it is a very much simpler matter to lay out a perspective with the object at 45°, it is usually best to arrange the station point at this angle and to set the object to the right or left of the center of vision in order to expose either side more or less to view. The station point in a 45°

perspective is located at its maximum distance from the picture plane, which is always a decided advantage, and the distance from the station point to the picture plane is equal to one-half of the distance between the principal vanishing points (rule V).

57. Symmetry of the 45° Arrangement.—Therefore, as S is equidistant from $v\,l$ and $v\,r$, it follows that $m\,l$ and $m\,r$ are equidistant each side of v, thus causing the vanishing points $V a$ and $V b$ to be the same distance above the horizon, and their corresponding points $V y$ and $V z$ to be an equal distance below the horizon. The traces of the planes $T\,L\,b''$ and $T\,R\,y''$ are parallel, as are also the traces of the planes $T\,R\,a''$ and $T\,L\,z''$.

58. Application of the Octagon.—Another point of simplicity in this arrangement is found in the ease with which the various measuring points and vanishing points

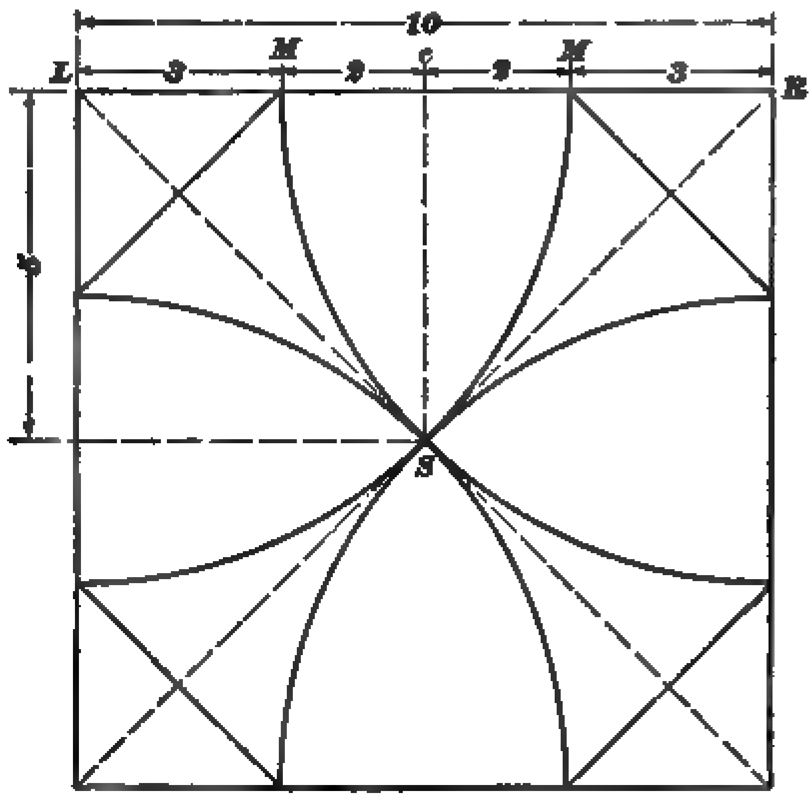


FIG. 20.

may be located, it not being necessary to lay out these details on a large sheet, as will be seen by reference to Fig. 20, which is simply a diagram of one of the methods of laying

out an octagon geometrically. From the four corners of a square a distance is laid off on each side equal to one-half the diagonal, thus locating points from which lines may be drawn to cut off the corners of the square to reduce it to an octagon. The section of the square *L S R* will be found to correspond exactly with our horizon line and station point, and the distances laid off on the side *L R* will be found to correspond exactly with the distances laid off for the measuring points on our horizon.

59. Standard Proportions.—Therefore, it may be assumed that, for all practical purposes, in laying out a perspective at 45° the distance from the horizon to the station point is equal to one-half the length of the horizon; the distance from the center of vision to the measuring points is one-fifth the horizon, and the distance from the measuring point to the nearest vanishing point is three-tenths the horizon. In other words, if the distance from *V L* to *V R* is divided into ten equal parts, then from *S* to *C* will be five parts, from *C* to *M R* will be two parts, and from *M R* or *M L* to *V L* or *V R* will be three parts.

60. Application of the Plane of Measures.—The student will now lay out, in accordance with Fig. 19, the vanishing points *V L* and *V R* at the extremities of a horizon not less than 8 inches long. Below this horizon he will draw a perspective plan of the house from which he can get the measurements to proportion the perspective elevation. In order to lay out this plan, it is simply necessary to get perspective widths by drawing lines from the principal parts of the plan above to the station point *S* and then construct the outline in precisely the same manner that the outline of the perspective views of the crosses in Fig. 8 was constructed. But he can do more than this. By drawing the line *g h* he can make a plane of measures whereon all the horizontal dimensions of any part of the house may be laid off and transferred to the perspective view of the plan by means of the measuring points *M L* and *M R*.

61. The corner of the house *c* in the upper plan is in contact with the picture plane *P P*, and lines drawn from the corners *a* and *b* to the station point *S* intersect the picture plane at points that mark the horizontal dimensions of the sides of the house in perspective. It has already been demonstrated that all parts of an object in contact with the picture plane may be laid off in the actual scale or dimensions of the object itself. In the same manner, in the lower perspective plan, we have the corner of the house in contact with this plane of measures, which is coincident with the picture plane, and can lay off any dimensions on that to the right or left of the corner, and transfer them to the perspective plan of the house by drawing a line toward the respective right or left measuring point, according to which side of the house the dimensions apply.

62. For instance, the length of the house is laid off from *k* to *g*, and the distances *k l* and *l m* correspond with the scale distances from the corner of the house to the break in its front and to the width of the break itself. Lines drawn from *l*, *m*, and *g* to *M L* locate the position of these details on the side of the house *k o*, as shown. The width of the end of the house is laid off from *k* to *h*, and a line from *h* to *M R* limits the width, in perspective, of the side of the house *k p*. The reasons for this will be explained more fully as we progress.

63. The front gable in the perspective elevation has been made a trifle different from the previous elevation in order to illustrate the convenience of the 45° position. It is seen that the slopes of the roof toward $V b^{60}$ and $V b^{60}$ are very readily set off above the horizon, as are the similar slopes $V a^{60}$ and $V a^{60}$.

64. The intersection of the two 60° slopes of the roof produces a line that has its vanishing point at the intersection of the traces of the two planes in which these slopes lie; in other words, at the intersection of $T L b^{60}$ and $T R a^{60}$. This vanishing point is marked V^{60} and is the vanishing

point of all hips and valleys intersecting at the 60° slope. The vanishing point of the intersections of the 30° slopes is shown at V''', where $T R a'''$ and $T L b'''$ intersect. The corresponding vanishing points below the horizon will be found at the intersections of the traces of the plane $T L z$ and $T R y$, toward which the valleys and hips of the opposite side of the house incline, but as these are not seen in this view, it is not necessary to show these points.

65. The student is advised to go over all these explanations very carefully and to familiarize himself thoroughly with all the details. Having understood the character and purpose of each vanishing point, he will give his attention to the division of the lines and their relative magnitudes in connection with these vanishing points.

DIVISION OF LINES.

66. The division of vertical lines in perspective presents no difficulty, because the line is parallel to the picture plane and may be divided into two, three, or four equal parts, or into other relatively proportional parts, by direct measurements; but the division of horizontal lines that recede from the eye is more difficult, as the subdivision most distant is shorter than the portion nearer the eye, and it is not always clear how much difference there should be.

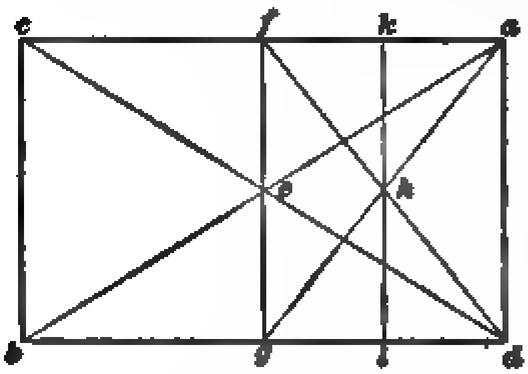
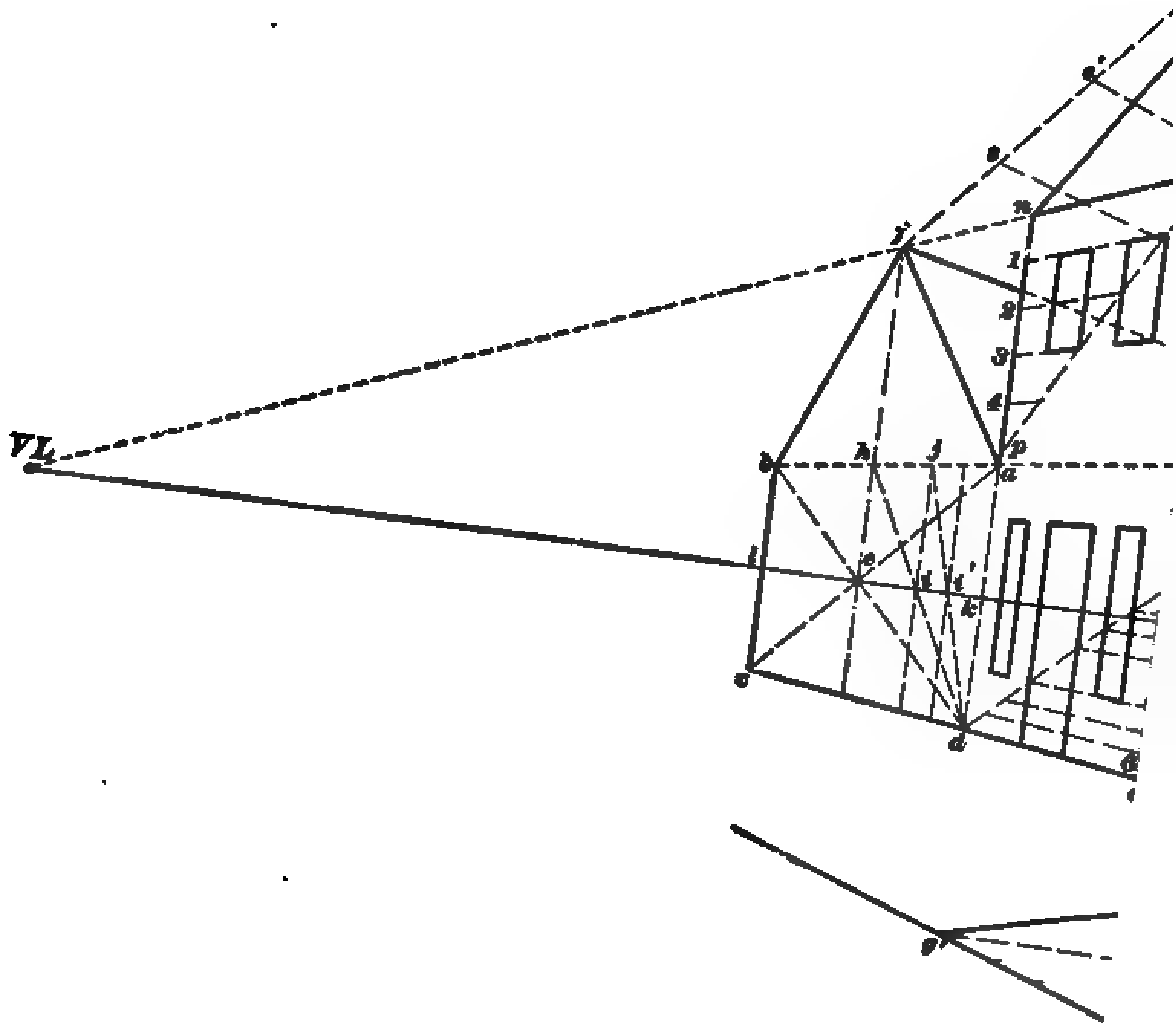


FIG. 21.

Two methods to determine these relative proportions have been adopted—one, known as the *method of diagonals*, and the other as the *method of triangles*.

67. The method of diagonals is based on certain geometrical properties of the parallelogram, and can be considered under five cases.



FIG

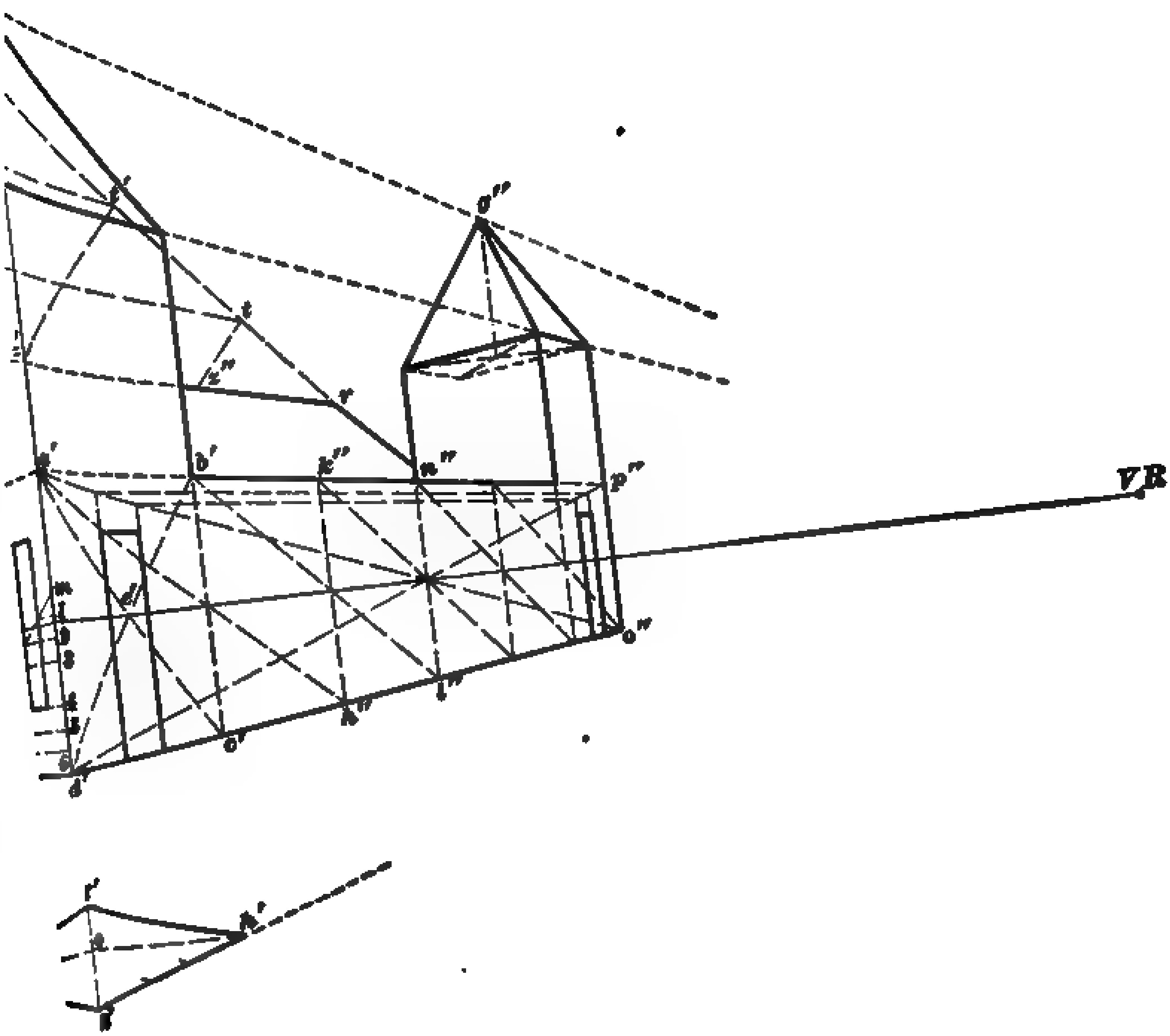


FIG. 12

68. Case I (Fig. 21).—The diagonals of a parallelogram intersect at the center of the parallelogram and a line drawn through their point of intersection, parallel to two of its sides, will bisect the other two sides of the parallelogram and also the parallelogram itself. The diagonals *a b* and *c d* of the parallelogram in Fig. 21 intersect at *e*, and the line *f g* drawn through their point of intersection *e*, parallel to the sides *b c* and *a d*, bisects the sides *a c* and *b d* and also the parallelogram itself, as shown.

In the parallelograms formed by means of the line *f g*, we have the diagonals *a g* and *d f* intersecting at *h*, and the line *k l*, drawn through the point of intersection *h* parallel with the sides *f g* and *a d*, bisecting the sides *a f* and *d g* and also the parallelogram *a d g f*.

69. By this method of diagonals we see that we have divided the line *a c* into two equal parts by the line *f g*, whereas the distances *a k* and *k f* are each equal to one-quarter the line *a c*. The subdivision of this line into eighths, sixteenths, etc. can be readily carried out by subdividing the parallelograms formed by the diagonals, as shown.

70. The application of this case to a perspective drawing is shown in Fig. 22, where we have, at *a b c d*, the side of a building in the form of a parallelogram. The diagonals *a c* and *b d* intersect at *e*, thus marking the center of this parallelogram, and the line *e f* drawn parallel with the vertical sides must pass through the center of the gable—the height of which we lay off on the corner of the building at *f′*—and by means of a vanishing line drawn from *f′* to the vanishing point *V L* it must locate the point of the gable at *f* without further consideration of the plan.

71. In the same manner we can locate the position of the point of the tower *g* by means of the diagonals *g′ h′* and *k′ l′* in the plan, these diagonals intersect at *o*, showing directly the position of the apex at the point of the tower

roof. The location of the apex of the more distant tower, shown at g'', is found in the same way, the diagonals not being drawn in the ground plan, as the perspective ground plan does not extend to that part of the building, but a plan is drawn at the top of the tower itself, as shown, and a vertical line erected at the intersection of the diagonals.

72. Case II (Fig. 23).—If through the intersection of the diagonals of a parallelogram a line is drawn parallel to two of the sides, a single line will thereafter be sufficient to establish any equal subdivisions of the other two sides, as shown in Fig. 23, where the line $a\,b$ is drawn through the intersection of the diagonals of the parallelogram at c, and the diagonal $d\,e$ intersecting the line $b\,c$ at f bisects the line $b\,c$ and also the smaller parallelogram $e\,g\,d\,h$. A line drawn through f parallel to $e\,g$ will give us precisely the same subdivisions in the parallelogram, Fig. 23, that we obtained in Fig. 21 but with fewer construction lines.

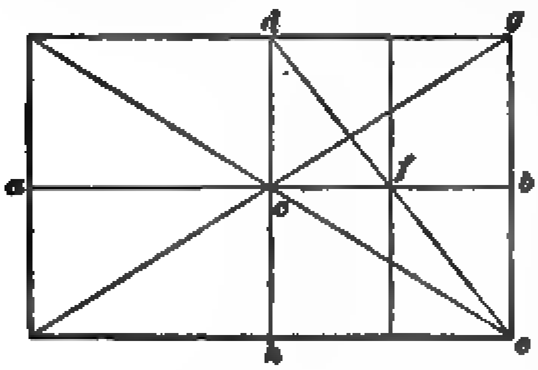


FIG. 23.

73. The application of this case in Fig. 22 is shown in the subdivision of the rectangular side $a\,b\,c\,d$, where the line $k\,l$ is drawn through the point of intersection of the diagonals at e toward the vanishing point at VL. A diagonal drawn from d to h will then bisect the line $c\,k$ at i, and a diagonal drawn from d to j will bisect the line $k\,i$ at i', thus subdividing the rectangle $a\,b\,c\,d$ into two equal parts by the vertical line through e, into four equal parts, if desired, by vertical lines through i, and into eight equal parts by vertical lines through i'.

74. Case III (Fig. 24).—If a line be drawn from a corner of a parallelogram through the center of one of the opposite sides of the parallelogram and continued until it intersects with the other opposite side prolonged, the length

of that side may thereby be doubled and likewise the parallelogram itself.

75. In Fig. 24, we have a parallelogram *a b c d*, from the corner *a* of which we draw a line *a f* passing through the center *e* of the opposite side *c b* and intersecting the opposite side *d c*, prolonged at *f*. The distance *c f* is, therefore, equal to *c d*, and the parallelogram constructed at *c f g b* is equal to the parallelogram *a b c d*. If we now draw the line *j k* through the intersection of the diagonals of the parallelogram *a b c d*, and from *j* draw a line through *e*, the center of *b c*, thereby locating the point *l* on the line *d c* prolonged, the distance *c l* is equal to the distance *c k*, and the parallelogram *c l m b* is equal to the parallelogram *k c b j*, which is one-half the parallelogram *a b c d*. In this manner we have increased the original parallelogram one-half in the latter case, and doubled it in the first case.

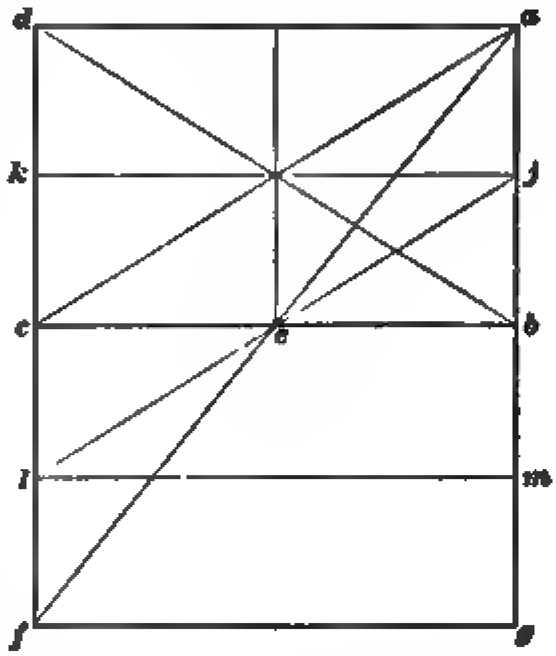


FIG. 24.

76. The application of Case III is shown in Fig. 22 on the right side of the building where, at *a′ b′ c′ d′*, we have a parallelogram forming the side of the tower, and the diagonals *d′ b′* and *a′ c′* intersect at *e′* and mark the center of the parallelogram through which a line is drawn to the vanishing point *VR*.

If from *a′* we draw a line through the center of the side *b′ c′* and continue that line until it intersects with *d′ c′* prolonged at *h″*, we can construct another rectangle *b′ c′ h″ k″* that is equal, in every respect, to the parallelogram *a′ b′ c′ d′*. And, again, drawing a line from *b′* through the center of the side *k″ h″* until it intersects with the line *c′ h″* prolonged

to l'', we can construct another parallelogram $k'' h'' l'' n''$; and so on to the completion of that side of the building, the entire side consisting of six parallelograms, each equal to $a' b' c' d'$.

77. Case IV (Fig. 25).—If the side of a parallelogram is divided, in any manner, near one end, equal subdivisions may be laid off near the other end by means of the diagonals.

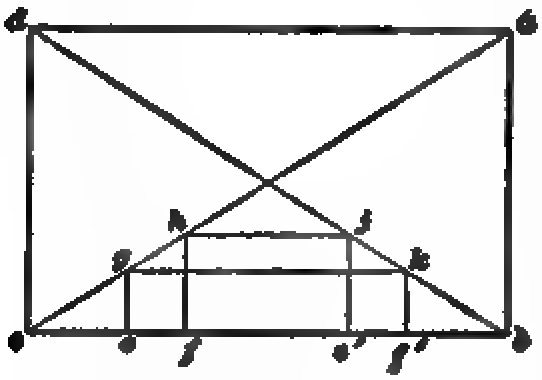


FIG. 25.

In Fig. 25 we have, in the parallelogram $a\,b\,c\,d$, the diagonals $a\,c$ and $d\,b$, while at $e\,f$ are two points on the side $c\,b$ nearer the end c. If the lines $e\,g$ and $f\,h$ are drawn parallel to the side $c\,d$ until they intersect with the diagonal $a\,c$ and from these points of intersection the lines $h\,j$ and $g\,k$ are drawn until they intersect with the diagonal $d\,b$, lines drawn from the points j and k parallel to the side $a\,b$ will intersect the line $b\,c$ at e' and f', so that the distances $b\,f'$ and $e'\,f'$ will be equal to the distances $c\,e$ and $e\,f$.

78. The application of Case IV in Fig. 22 is shown in the location of the door openings in the two towers, where the side lines of the door of the nearest tower are continued upwards until they intersect with the diagonal $a'\,o''$ of the parallelogram $a'\,p''\,o''\,d''$, and from these points of intersection vanishing lines are drawn toward VR until they intersect with the diagonal $p''\,d''$, and vertical lines drawn from these latter points of intersection will mark the width of the door in the more distant tower, as shown.

79. Case V (Fig. 26).—If one side of a parallelogram is subdivided into parts of any relative proportion, either of the adjacent sides may be divided in the same proportion by means of one of the diagonals, and the relative positions of these proportional parts may be in the same, or the reversed, order, according to which of the diagonals is used.

In Fig. 26 we have a parallelogram *a b c d* the end of which is divided at *e* and *f*. If we draw lines from *e* and *f* parallel to the side *a d* until they intersect with the diagonal *b d*, and from these points of intersection draw lines parallel to the side *d c*, these lines will subdivide the side *a d* at *e'* and *f'* so that the proportions of *d e'*, *e' f'*, and *f' a* will be the same as the proportions of *d e*, *e f*, and *f c*. Or, if from *e* and *f* we draw lines parallel to *a d* until they intersect with the diagonal *a c*, and from these points of intersection draw lines parallel to the side *d c* and intersecting the side *b c* at *e''* and *f''*, the subdivisions of the line *b c* will be proportional to the subdivisions of the line *c d* but in the reversed order from the subdivisions, as laid out on the other diagonal for the line *a d*.

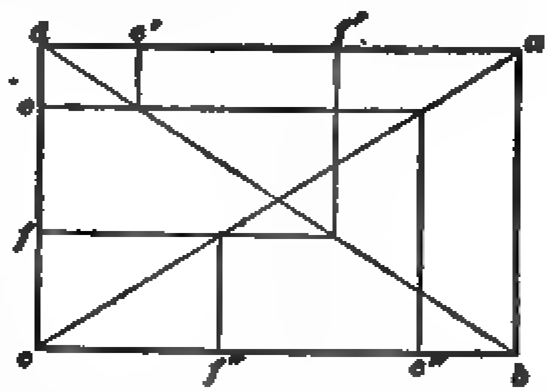


FIG. 26.

80. The application of this case to Fig. 22 is shown in the location of the windows on each side of the door opening in the nearer tower. The distance *m d'* on the corner of the tower is laid off equal to the scale width of the tower in elevation, and at *m–1*, *m–2*, *m–3*, etc. are laid off the scale measurements of the windows and doors, *m–1* being the scale distance from the corner of the tower to the edge of the window, *1–2* the width of the window, *2–3* the space between the window and the door, *3–4* the width of the door, etc. Lines drawn from *1*, *2*, *3*, *4*, etc. toward the vanishing point *VL* intersect the diagonal *m d* at points through which vertical lines may be drawn to establish the width of the windows and door.

81. It is evident from this that a definite length of a given parallelogram in the perspective drawing is unnecessary, as the line *a' d'* can be laid off in any place and at any convenient length, so long as its subdivisions may

be carried toward a vanishing point and intersected by a diagonal.

82. For instance, on the farther corner of the left-hand side of the tower there are laid off, from *n* to *p*, certain subdivisions corresponding with the width of the windows and the spaces between them in the upper part of the tower. A diagonal then drawn from *p* to *f′* furnishes a line on which the subdivisions between *n* and *p* may be laid off for the windows, by means of vanishing lines drawn from *VL* through the subdivisions between *n* and *p* to intersect on *p f′*. The distance *n p* may be laid off arbitrarily, longer or shorter, as here shown, and the subdivisions *n-1*, *n-2*, *n-3*, etc. may be at any convenient scale, so long as the total distance *n p* equals the scale width of the tower in elevation. The line *n f′* is fixed, however, as it represents the width of the tower in perspective, and lines drawn from the vanishing point *VL* through the subdivisions of the scale width of the tower *n p* will intersect on the diagonal *p f′*, so as to locate the subdivisions across the apparent width of the tower in perspective.

83. In the application of each of these five cases we have considered all lines running to the same vanishing point as being parallel, whereas all vertical lines actually are parallel, and if the student will bear this well in mind he will never have any difficulty in transferring measurements from his scale elevations to his perspective surface.

84. The Method of Triangles.—In the application of the last case it will be observed that only one-half of the parallelogram has been used, and though the principle involved is that of the diagonal of a parallelogram the problem resolves itself into the use of a triangle.

Therefore, Case V might be stated definitely as follows: If one side of a triangle, as *d c*, Fig. 26, is divided into any relative proportions, the adjacent side *d a* may be divided into similar proportions by lines drawn parallel to the two sides and meeting on the third side *a c*.

85. The last application of this case also gives rise to a proposition, that if from one end of any given line in a perspective drawing, another line is set up parallel to the picture plane, any subdivisions laid off on the line so set up may be transferred, proportionately, to the given line on which it is set up by means of a third line connecting the last point taken on the set-up line and the other end of the line.

86. The application of this principle in Fig. 24 is shown in the location of the lightning rods along the roof of the building at $f r$, where from f, a line $f x$ is erected arbitrarily and divided into three equal parts at s and s', and from x a line is drawn to r, completing the triangle $f x r$. This triangle may be of any size or proportion but the side $f r$ must always be the same. Lines then drawn from s and s' to the vanishing point VR (VR being the vanishing point of the given line $f r$) will intersect the line $x r$ at points t' and t, from which points of intersection lines drawn parallel to $f x$ will intersect the given line $f r$ at points s' and s'', which mark the location of the lightning rods along the ridge.

87. This same principle may be used at any time to locate any number of equal or proportional subdivisions in any perspective line whatever, thus eliminating from the perspective plan much detail that would otherwise be required.

THE PLANE OF MEASURES.

88. We have already learned that any part of an object in contact with the plane of measures may be laid off to a proportional scale direct; and if the object is drawn full size, the plane of measures will coincide with the picture plane and the details of the object in contact with the picture plane may be laid off to a full-size scale. On the other hand, if we consider that instead of the object itself we have a small model of it on a scale of $\frac{1}{4}$ full size or a much reduced scale of $\frac{1}{8}$ or $\frac{1}{16}$ inch to the foot (as is usually the case with a house), and that this model is in contact with

the picture plane, then we may consider the picture plane a plane of measures, and the full-size drawing of the *model*, at $\frac{1}{16}$-inch scale, will represent the appearance of the actual object as it would be projected on the picture plane placed 192 feet in front of it.

89. In Fig. 19 we have the corner *c* of the house plan in contact with the picture plane PP, and therefore all measurements on this corner of the house may be taken to actual scale in the perspective drawing. As this scale is $\frac{1}{16}$ inch to the foot, or $\frac{1}{192}$ of the full size, we may consider this as a small model, and the picture plane PP becomes a plane of measures and the perspective will represent the object as though it were 192 feet beyond the picture plane.

Therefore, in the perspective elevation, Fig. 19, we have drawn a vertical line *t t* as the line of measures where the corner of the house *c* touches the plane of measures, and from the bottom of this line we have laid off the distance *t u* 21 feet in height; that being the height of that corner of the house; and the distance *u w* 12 feet, that being the vertical height of the lower slope of the roof as shown on the elevations; and the distance *w t* is 7 feet 6 inches, as shown on the elevation. Lines drawn from the points *u*, *w*, and *t* toward VR establish the lines of the top of the plane wall, of the hips of the roof, and of the peak of the gable, where t–VR intersects the vertical center line through the front of the gable, which is located by means of the diagonals from *t* and *u*.

90. Inasmuch as the vertical line through the corner *c* is in the plane of measures and serves as a line of measures, it stands to reason that a horizontal line in the plane of measures can be used as a line of measures and dimensions laid down thereon transferred directly to any of the horizontal lines in perspective. This is very simple where the lines in question are parallel to the horizon and also to the picture plane, but where the lines recede and are at an angle with the picture plane, the problem is somewhat

different and we adopt a principle somewhat analogous to our principle of triangles, for dividing lines and surfaces, that has been heretofore explained.

91. It is very evident that if we lay off from the corner c of the building, on the picture plane PP, the distance $c\,a'$ equal to the length of the house $c\,a$, and draw the line $a'\,a$, that the triangle $a\,a'\,c$ is an isosceles triangle and that lines drawn parallel to the base $a\,a'$ will divide the sides $a\,c$ and $a'\,c$ into exactly equal parts, as shown by the lines $l\,k'$ and $m\,g'$. Therefore, if we stand at S and look in a direction parallel to $l\,k'$, $m\,g'$, and $a'\,a$, we will see the vanishing point of this system of lines that are parallel to the base of the triangle and in that we will have the key to the solution of transferring these distances in the perspective plan below.

Further consideration will show that this vanishing point coincides with $m\,l$, because the lines from the station point S to the vanishing points $v\,l$ and $v\,r$ are parallel to the sides of the house by construction, and that the distances $v\,r$–$m\,r$ and $v\,l$–$m\,l$ are equal to the distances $v\,r$–S and $v\,l$–S. Therefore, the triangle $v\,l$–$m\,l$–S is isosceles with its three sides lying in exactly the same directions as the three sides of the triangle $a\,a'\,c$, and $a\,a'$ and S–$m\,l$ are parallel.

92. If, therefore, below the horizon we assume any line $g\,k$ as coincident with the plane of measures, we can lay off from some point k distances to the left and right and transfer those distances to lines vanishing in VR and VL. As k coincides with the corner of the house, and the distances $k\,l$, $k\,m$, and $k\,g$ correspond with the distances $c\,k'$, $c\,g'$, and $c\,a$ in the upper plan, we can draw lines from l, m, and g toward $m\,l$, which will be the perspectives of the lines $a'\,a$, $m\,g'$, and $l\,k'$. In the same manner we can lay out the points between k and h representing the window openings on the end of the house, and by drawing lines from them toward $m\,r$ indicate the positions of these window openings in the perspective plan, as shown.

93. The simplicity brought about by all these details is

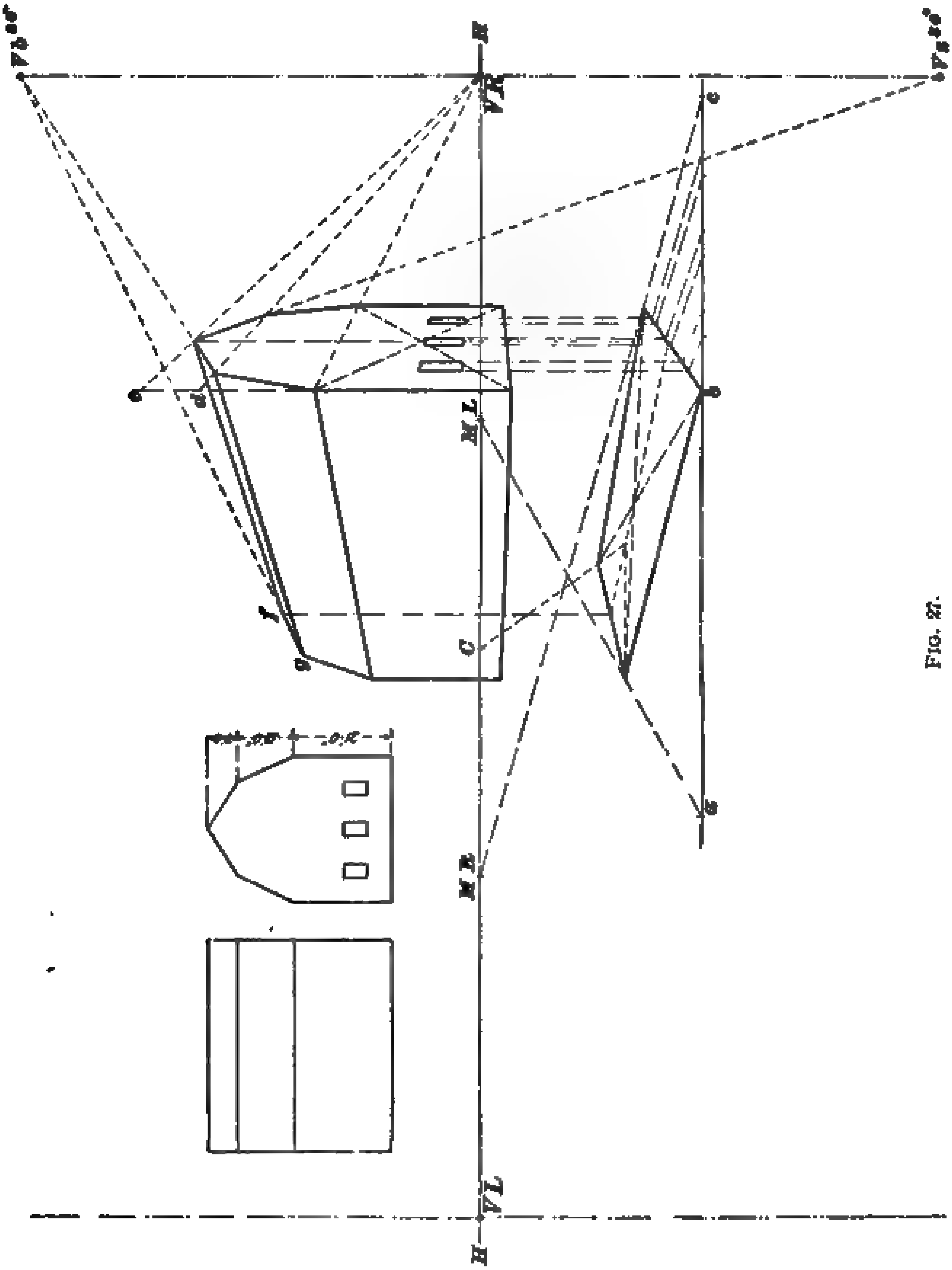


FIG. 27.

shown in Fig. 27, where at HH we have laid out our horizon line 10 inches in length, and from its center C we have

laid out the two measuring points *M R* and *M L*, according to the proportions given in Fig. 20. At *a b c* a line is drawn at any convenient distance below the horizon and from *b* toward *a* the details of the front of the house are laid off, while from *b* toward *c* are laid off the details of the end of the house, as was previously explained in connection with the plane of measures. Lines drawn from the divisions on *b c* toward *M R* subdivide the perspective view of the end of the house, and similar lines drawn from the divisions on *a b* toward *M L* subdivide the front of the house. We are thus able to locate and proportion the two sides of the house and the details they contain.

94. By drawing diagonals through the parallelogram forming the end of the house, the vertical center line is located and thereby establishes the position of the point of the gable. The corner of the house being in contact with the picture plane, we can measure on that, at *d* and *e*, the heights of the two slopes of the gable as shown on the front elevation, and where a line from the highest point *e* toward *V R* intersects this vertical center line we have the peak of the gable. *V b* and *V s* are readily located from *M R* by means of a 30° triangle, and the slopes from the peak of the roof toward *V b* and *V s* can be laid out, and at the same time establish by their intersection with the line from *d* to *V R* the points where the lower slope of the roof intersects, thereby obviating the necessity of using the vanishing points of the 60° slope of the roof when these points are so inaccessible.

95. Diagonal lines through the plan locating its center and the line through this center toward *V L* locate the center of the gable on the opposite end of the house, a vertical line from which will intersect with the ridge and mark a point *f* where the 30° slope can be laid off on that end, and the intersection of this, at *g*, with the line drawn from the hip of the roof to *V L* will give us all the information required for the slope on this end.

96. We have drawn the complete outline of our object without recourse to all the complicated projections shown in Figs. 17 and 18 and without projecting any lines from the actual plan, depending entirely on our perspective plan and line of measures. This is not advisable where a perspective is complicated and difficult, but it is a matter of great convenience where small sketches must be hurriedly made.

PARALLEL PERSPECTIVE.

97. Difference Between Parallel Perspective and 45° Perspective.—We will now consider the perspective rendering of objects whose sides, instead of inclining at an angle of 45° with the picture plane, as in the last cases, are perpendicular to the picture plane; in other words, rectangular objects that are so placed that one side is parallel with the picture plane, and the other side at right angles to it. In 45° perspectives, *V L* and *V R* are equidistant from *V* and *C*, and the measuring points *M R* and *M L* are also symmetrically disposed on each side of the center. In parallel perspective we can assume the same layout of the various points, but the main vanishing point will be *V* in the center of the picture, and *V L* and *V R* will then become the vanishing points of 45°, as will be pointed out presently.

98. In Fig. 28, we have the plan of a courtyard surrounded by buildings, as shown at *a b c d*, the sides *a b* and *d c* of which are perpendicular to the picture plan *P P*, and the side *b c* is parallel to the picture plane. It has already been explained that all lines in a plane parallel with the picture plane can be measured in direct proportion to the actual lines that they represent, and that such a plane may be considered a plane of measures, and may coincide with the picture plane itself when desirable.

Therefore, the portions of the building in contact with the picture plane at *a* and *d* may be laid out regularly to the full scale of the plan, and the steps going up to the right from *d* may have their ends next the picture plane laid out

in their actual scale and proportionate size. The proportions of all parts of the building in contact with the picture

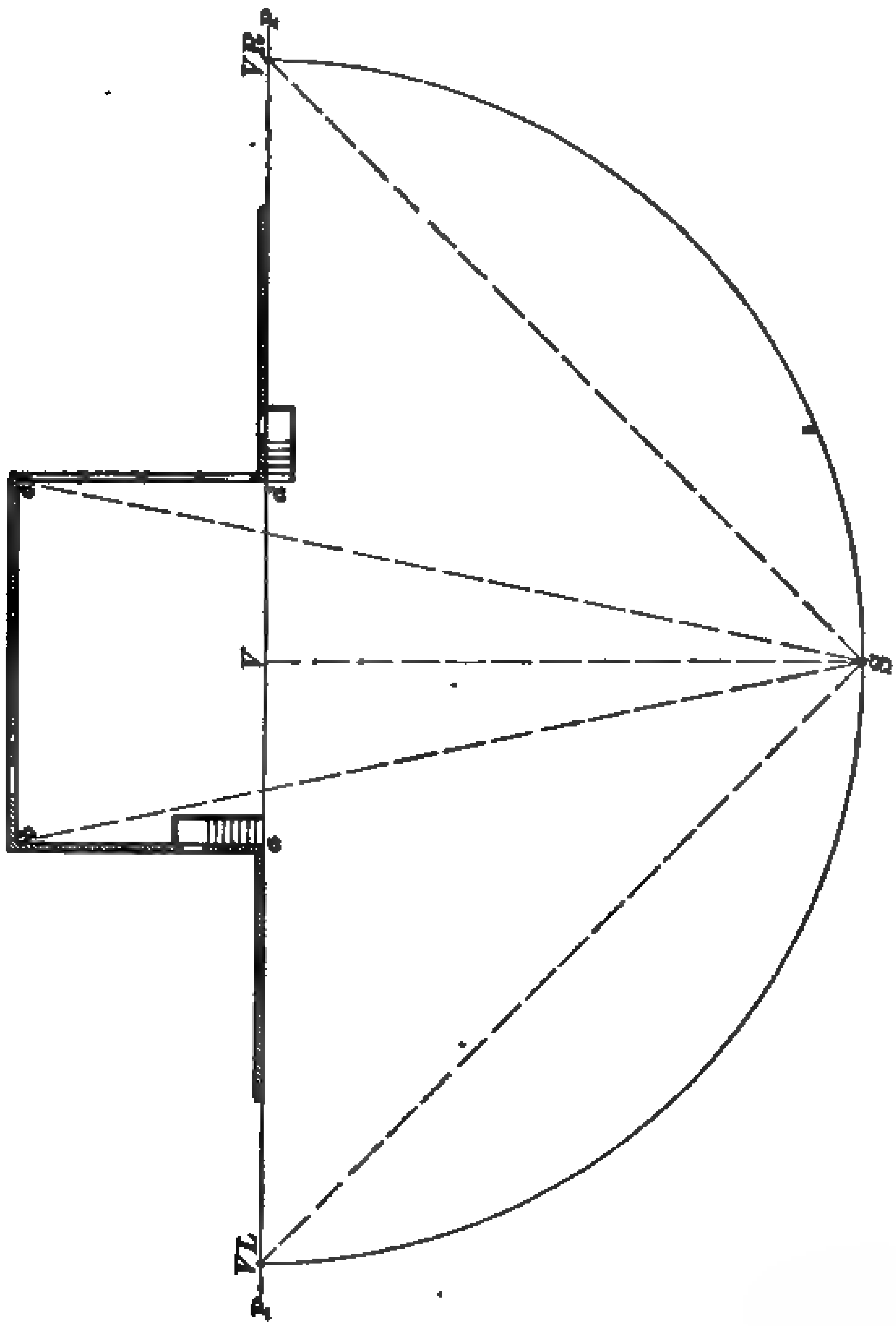


Fig. 33

plane may be laid out as a simple elevation and the relative lines projected therefrom toward the vanishing point *V*, so as

to intersect with vertical lines drawn to limit the perspective width of the buildings in the back of the courtyard, which are then, in themselves, drawn in elevation.

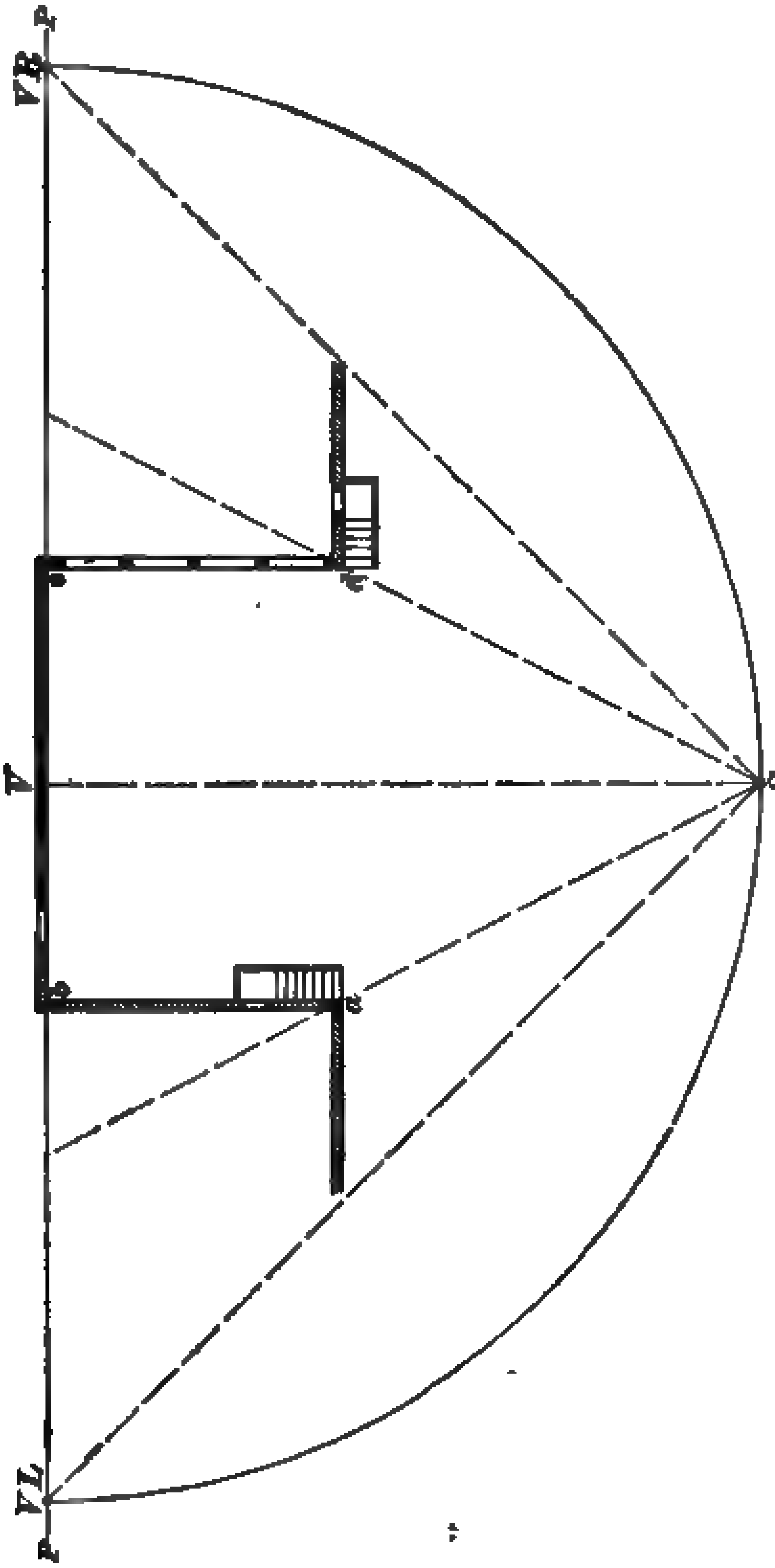


FIG. 22

99. Change of Position of Picture Plane.—It is not at all unusual, in making drawings in parallel perspective,

to reverse the order of things somewhat and to place the picture plane behind the object to be drawn, projecting the lines of sight from *S* back toward the object. This is shown in Fig. 29, where the picture plane is at *PP*, and the plan of the courtyard *a b c d* is entirely in front of it. The station point is at *S*, as before, and lines are drawn from the station point through the principal points of the building and projected back until they intersect with the picture plane. The advantage in this consists in the fact, that the entire facade of the building *b c* is in a plane of measures and can be drawn to scale as an elevation.

100. The effect of these arrangements, when working with a perspective plan, is in no way different, except in the laying out of the plan.

101. In Fig. 30, we have assumed as our horizon line *HH*, with *VL*, *V*, and *VR* located as in angular perspective, together with the measuring points *MR* and *ML* as shown. At any point convenient below the horizon (though in many cases the farther below the better), we draw the perspective plan of our courtyard as follows:

The elevations, or facades, of the buildings nearest us, as shown at *a a* and *d d* in the plan, are drawn to their full scale of $\frac{1}{16}$ inch or $\frac{1}{8}$ inch to the foot, according to the scale of the perspective we are making, the distance *a d* being the same as the distance *a d* in the scale plan shown in Figs. 28 and 29. The lines *a b* and *d c* converge toward *V*, and the perspective depth of the courtyard is ascertained by laying off from *a* toward *d*, a distance *a e* equal to the scale depth in the plan, Fig. 28, and drawing a line to the 45° vanishing point *VL*. This makes the triangle *a e b* the perspective view of a right-angle triangle with the right angle at *a* and the angles at *b* and *e* equal to 45°. Therefore, the side *a b* must equal the side *a e*.

102. Laying Out Plan of the Steps.—In the same manner we lay out the plan of the steps, the width of each

successive tread of the steps being laid out from *a* toward *f* and lines drawn toward *VL* to mark these widths on the side

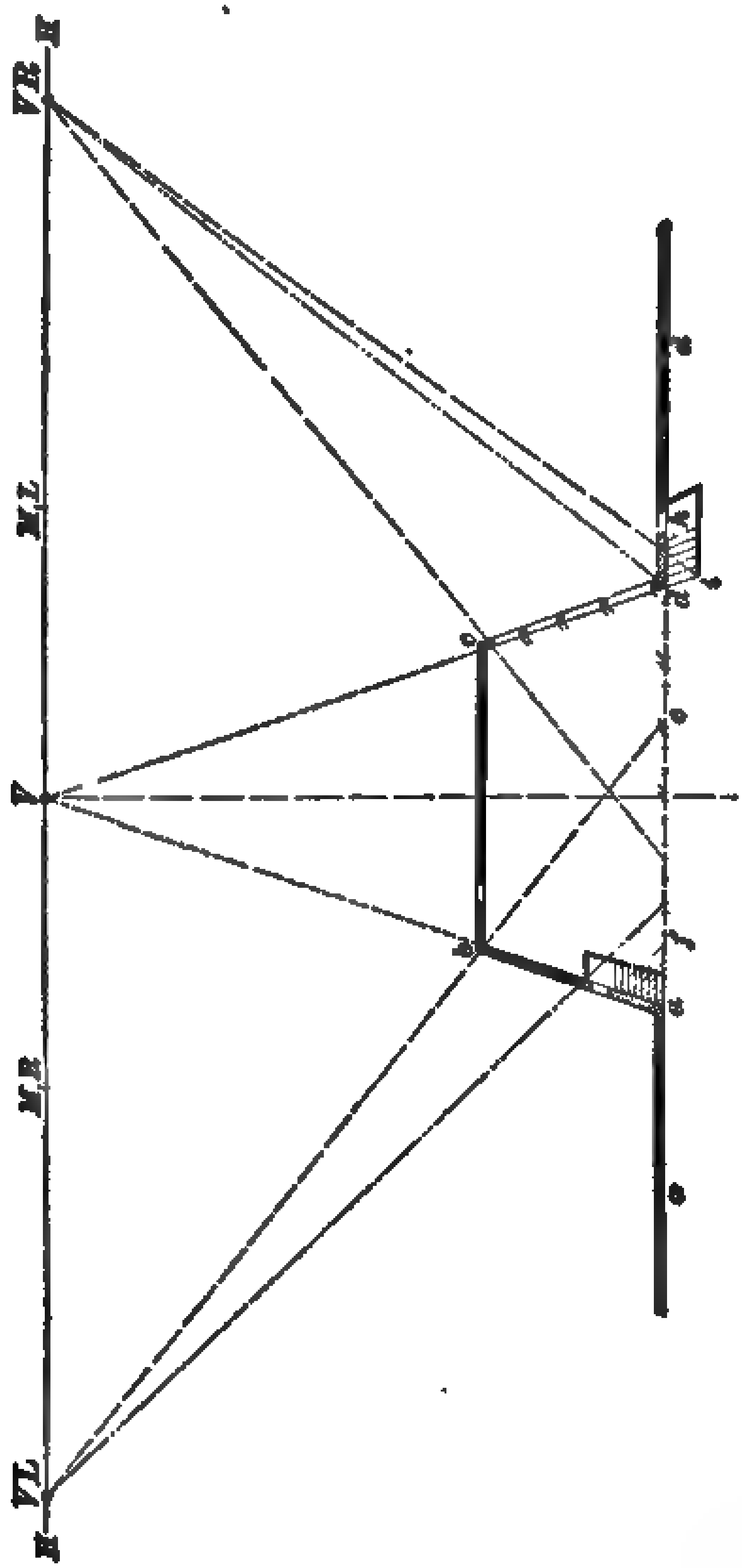


FIG. 30.

of the house *a b*. The width of the treads of the steps on the right side can be laid out to actual scale along the side of

the house $d\,d$, and lines drawn from V through them will mark them in plan, whereas their length beyond the line $d\,d$

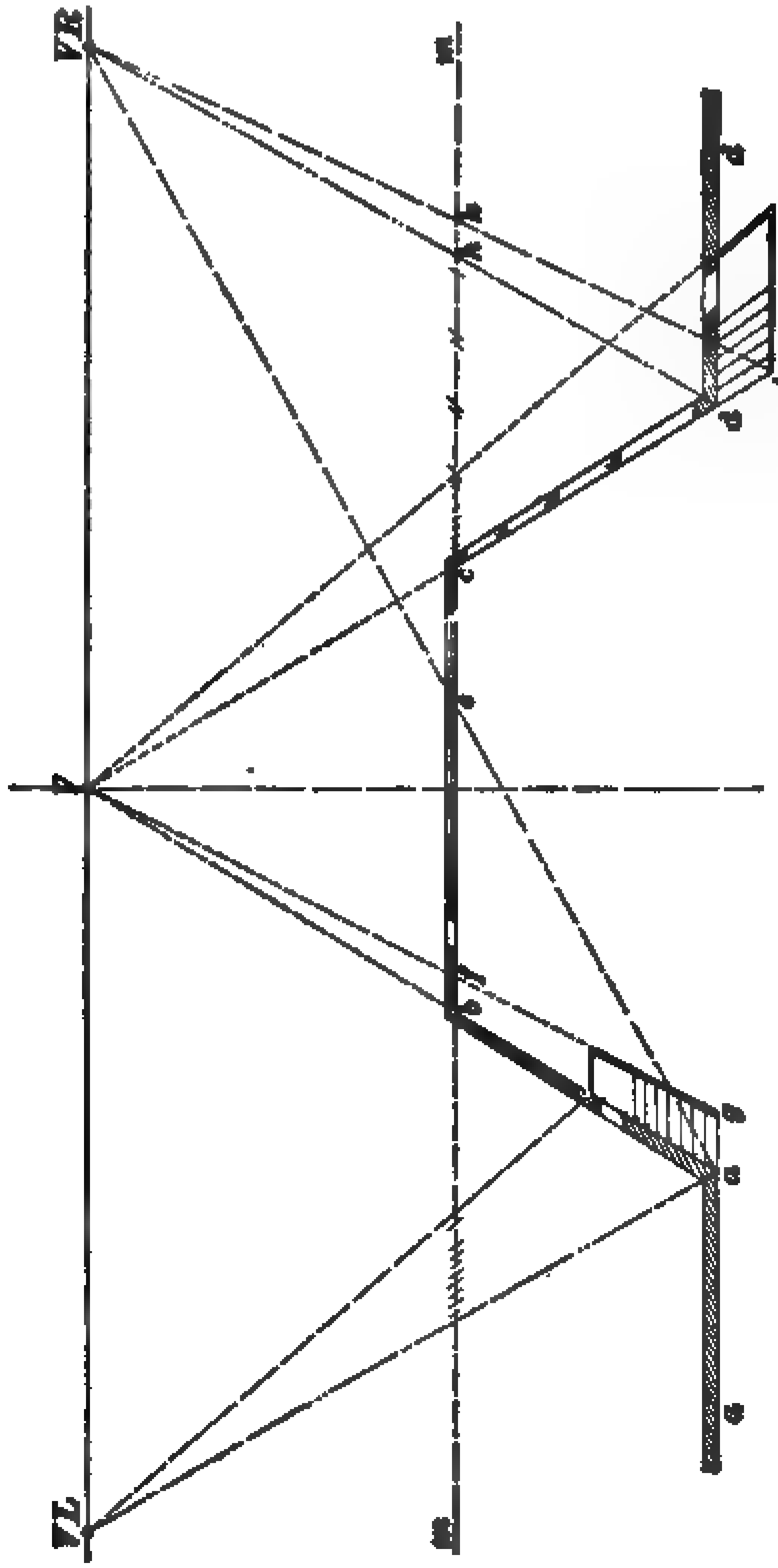


FIG. 31.

is determined, as before, by measuring off a distance from d to h equal to the width of the steps and drawing a line toward $V\,R$, thus making $d\,i$ equal to $d\,h$ and the triangle

d i h, a right-angle triangle in perspective with its right angle at *d*.

103. In Fig. 31, a perspective plan is laid out in precisely the same manner, except that we assume *b c* to be in the plane of measures, and lay out this end of the court to full scale, drawing lines from *V* through *b* and *c* toward *a* and *d* and determining the length of the side *a b*, as before, by measuring from *b* toward *c* a distance *b e* equal to the scale length of the side *a b*, also drawing through the point *e*, so located, a line from *VR*; constructing, thereby, in perspective, a right-angle triangle *a b e* with a right angle at *b* and 45° angles at *e* and *a*, making the side *b a* equal to the side *b e*.

104. As all lines drawn toward *VR* or *VL* are at 45° with the picture plane, and as all lines drawn toward *V* are at right angles with the picture plane, it stands to reason that a line from *d* to *VR* will be at 45° with *c d* and that the angles *c–d–VR* and *d–d–VR* are both 45°. If, then, from *h*, the point where the line from *d* to *VR* intersects the plane of measures *m m*, we lay off the distance *h k* equal to the width of the steps in front of *d d*, and draw from *VR* through *k* the line *k i*, we have, where this line intersects *c d* prolonged, the width of the steps, in perspective, at *d i*. The other steps by the corner *a* are laid out by measuring their scale width at *b f* and projecting it by means of a line from *V* through *f* to *g*.

105. Method Used in Practice.—In practice, where the plan is constructed in front of the plane of measures, as in this case, and there is much detail to be drawn upon the sides *a a* and *d d*, it is wise to construct a new scale for use on the sides *a a* and *d d*. This can be done by simply laying off, to scale, a few equal divisions of 1 foot each on the plane of measures *m m* and drawing lines from *V* through them until these lines intersect with a new plane of measures coincident with *a a* and *d d*. This will give a new scale of feet by which all the details of *a a* and *d d* may be laid out.

106. Changing the Scale.—While we are considering this point of a change of scale, there is another condition in which a change of scale is very convenient and often imperative. In Fig. 32, we have a room or hall, as shown at *a b c d*. The station point is at *S*, the picture plane at *PP*. In order to locate in a perspective plan certain points that will give

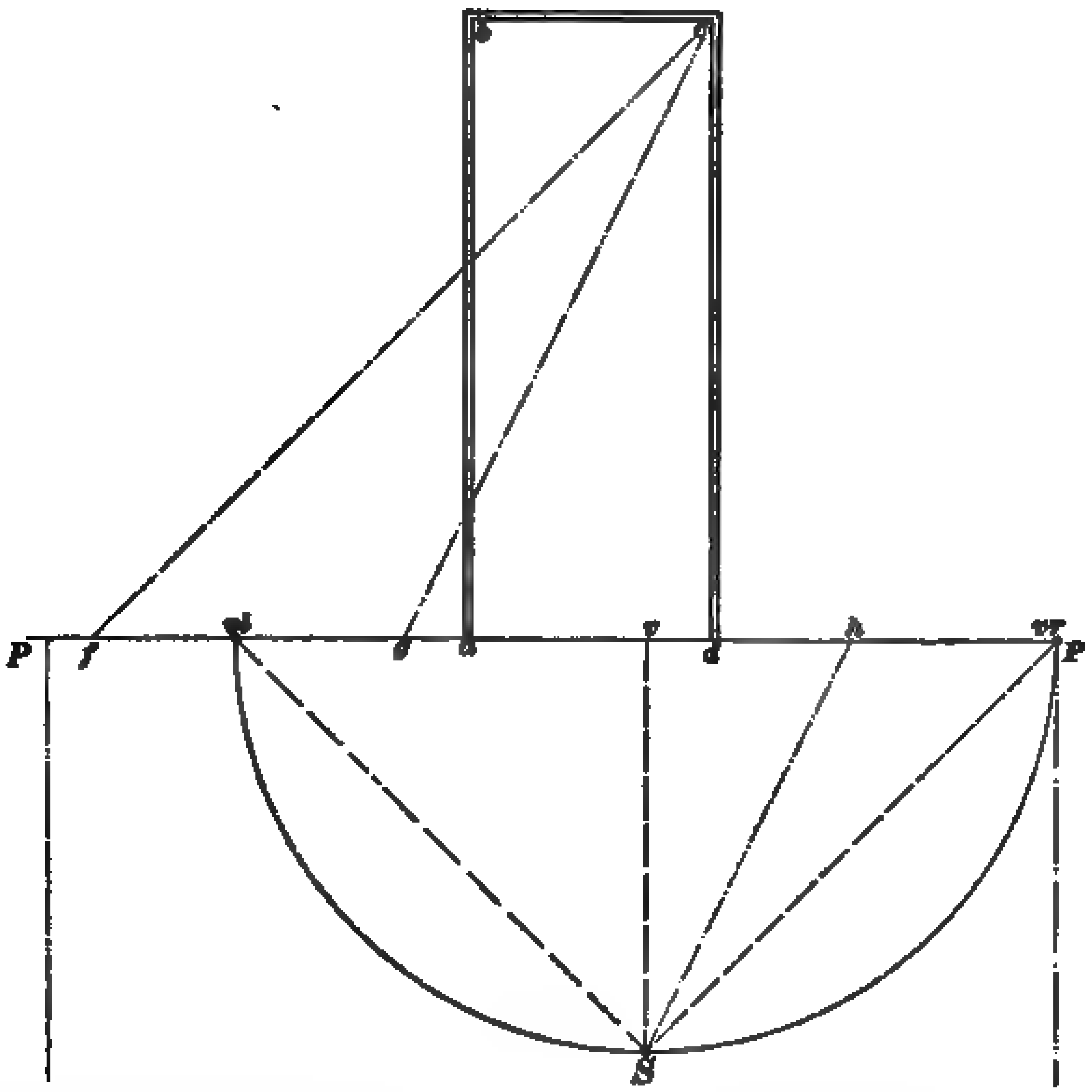


FIG. 32

us the depth of this room, it will be necessary to lay out, toward the left from *d*, Fig. 33, a distance *d f* equal to *d c* in Fig. 32 and draw a line from *f* toward the vanishing point *VR*. But circumstances might be such that we will not have space to lay out so great a distance to the left of *d* and can only get in one-half or one-quarter of this distance, according to the depth of the hall. Inasmuch as a line

drawn from *f* to *c*, Fig. 32, is parallel to the line from *S* to *v r*, it stands to reason that a line drawn from a point *g* half way between *d* and *f* toward *c* will be parallel to a line drawn from *S* to a point *h*, half way between *v* and *v r*.

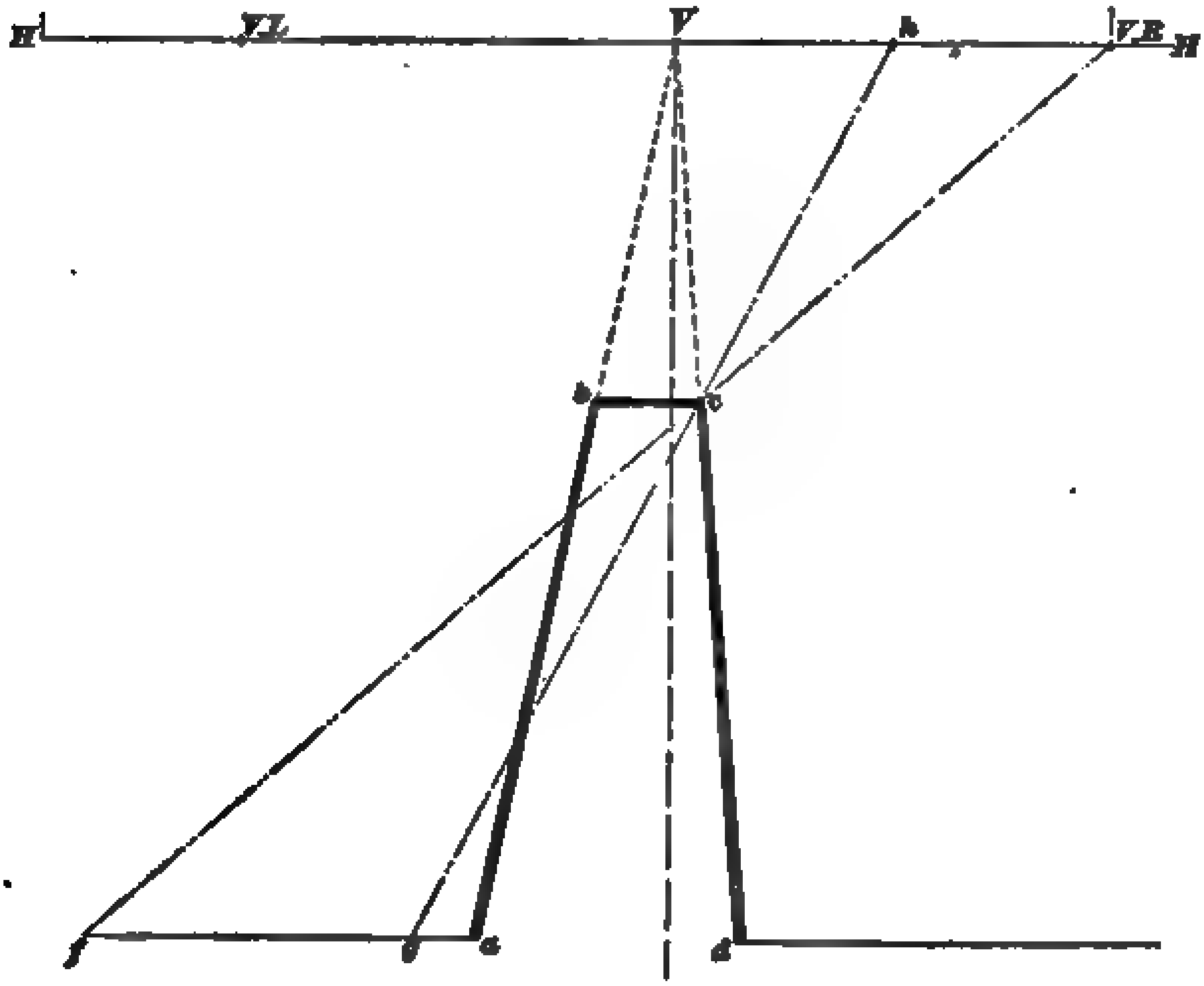


FIG. 32.

Therefore, in order to locate the depth of *d c* in perspective we lay off, to the left of *d*, a distance *d g* equal to one-half the distance *d c* and we draw from *g* a line *g c* parallel to a line drawn from *S* to a point *h* half way between *v* and *v r*. This line will locate the corner *c* for us, as before.

107. Determining Depth of Room.—Applying this principle again in our perspective plan, we have in Fig. 33 our horizon *H H* and the same arrangement of vanishing and measuring points as in the previous figure, and it is assumed that we have a deep room *a b c d* in perspective plan, the depth of whose side *d c* we are desirous of determining.

As we have not sufficient distance to lay out the actual scale length of *dc* toward the left, we lay out half of this length *dg* and draw a line from *g* to a point *h* half way between *V* and *VR*. This line will locate at *c* the depth of our room as required.

108. In Fig. 34 we have at (*a*) the perspective plan of the first story of the court and at (*b*) the perspective plan of the second story of the court, shown in Figs. 28 and 29, and above them, drawn in simple elevation, is that portion of the facade of the building that lies in the plane of measures coincident with *b c* of the plan. The steps at each side of the court are determined in the same manner as explained in Figs. 30 and 31, but it will be noticed that the facade of the second story *b′ c′* is narrower than that below, thereby showing that *c′ d′* projects slightly over and beyond *c d*. This illustrates very clearly the advantage of using a perspective plan, as all of these details of projection can be shown in their relative positions without the slightest confusion, and the entire plan can be laid out with perfect convenience and all points located for proper projection into the picture.

109. Determining Proper Method of Procedure. In determining which procedure is necessary in parallel perspective—that of having the plane of measures entirely in front of the object, as in Fig. 30, or that of having it entirely behind as in Fig. 31—consideration must be given to the amount of distance effect that it is desired to produce. In general practice it is convenient to determine the relative proportions of a street or interior in the very beginning. That is to say, having determined on a scale to which the nearest portions of the object are to be drawn, the most distant portions may then be drawn to any suitable size and set as far up or as far down, or to one side or the other, as will give them the best appearance. Vanishing lines then drawn through the corresponding angles of the two ends will determine *V* and the height of the horizon. This is all that need be determined there, as the length of the street or

room is known and the intermediate details may be afterwards proportioned.

The real length should now be laid off on the ground line

Fig. 34.

from the nearest end of the perspective of this length, and a line from the point thus located should be drawn through

the end of the perspective line and prolonged until it meets the horizon. This point will be *M R* or *M L* if the full distance is laid off, and one-half *M R* or *M L* if only half the distance is laid off. The corresponding distance of the station point in front of *V* can then be located with this data.

Fig. 35

110. A clearer idea of this proceeding may be obtained from Fig. 35, wherein the elevation of the back of the court-yard is shown drawn to scale and the general outline of the other details are arranged about it. Lines drawn from *a* and *d* through *b* and *c* meet at *V* and locate the vanishing point *V* and the height of the horizon. Other lines drawn from *V* to *x* and *V* to *y* give, in outline, a perspective plan *x u w y* from which *V L*, *V R*, *M L*, and *M R* may be located. From *x* we lay off to the right a distance *x g* equal to the actual scale depth of the court and draw a line from *g* through *u* until it intersects with the horizon line, the point of intersection will be *V L*, and the distance *V L–V* will be

equal to the distance from V to S, which is the station point.

111. It may seem somewhat irregular to make a drawing by this inverse method, especially after we have considered so carefully the importance of locating the station point and horizon line heretofore; but in parallel perspective, there being but one vanishing point, the effect is liable to be very deceptive, as the location of the station point is not naturally taken into consideration by the spectator, and the size and proportions of objects are judged by the effect of distance instead of from the point from which they are viewed.

Fig. 36 shows two perspective sketches made by this method; in one of them (*a*) the station point is twice as far away as in the other (*b*), and though they are both drawn to

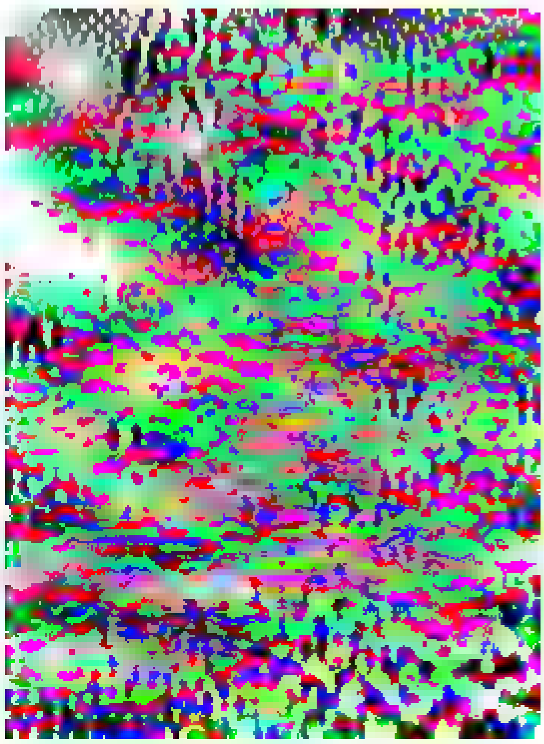


FIG. 36.

exactly the same scale the effect is materially different. So far as the lines of the drawing are concerned, the effect of distance is produced by placing the station point near to the nearest part of the object shown, thus producing considerable contrast between the relative sizes of the nearest object

and those most distant. This, however, though desirable in the representation of streets and halls, is undesirable in the representation of rooms of medium size. It is therefore better to move the station point away from the picture plane and to render the distant objects larger and more distinct, in order that they may not appear so remote.

PERSPECTIVE OF CIRCLES.

112. Difference in Perspective Drawing of Curved and Straight Lines.—So far we have considered only the perspective drawing of straight lines, whose vanishing points could always be located by looking in the direction of the line and observing where it pierced the picture plane. With curved lines, however, we have an entirely different condition of affairs, because, on account of their changing direction, they may not come into contact with the picture plane at all but will remain entirely beyond it.

113. Lines of sight, however, from the eye of the spectator to the contour of the curves will pierce the picture plane in such a manner as to locate a number of points that can be connected and represent the perspective of the arc. It will thus be understood that the spectator looking at the circle will have his lines of sight represent, in space, an imaginary cone, the base of which will be the circle in question, and the apex, the meeting of the lines of sight at his eye.

114. This is shown somewhat more clearly in Fig. 37, where the spectator, standing at S and regarding the circle $a\,b\,c\,d$, forms an imaginary cone of rays with his eye at the vertex and the circle at the base. If this cone of rays is cut through at any point by the picture plane as shown at PP, its intersection will be an ellipse, as shown at $e\,f$, as we have already learned that any section of a plane passing through two sides of a cone produces a circle or an ellipse. In perspective drawing all representations of the circle are either

ellipses, parabolas, or hyperbolas, according to the position of the spectator with reference to the circle.

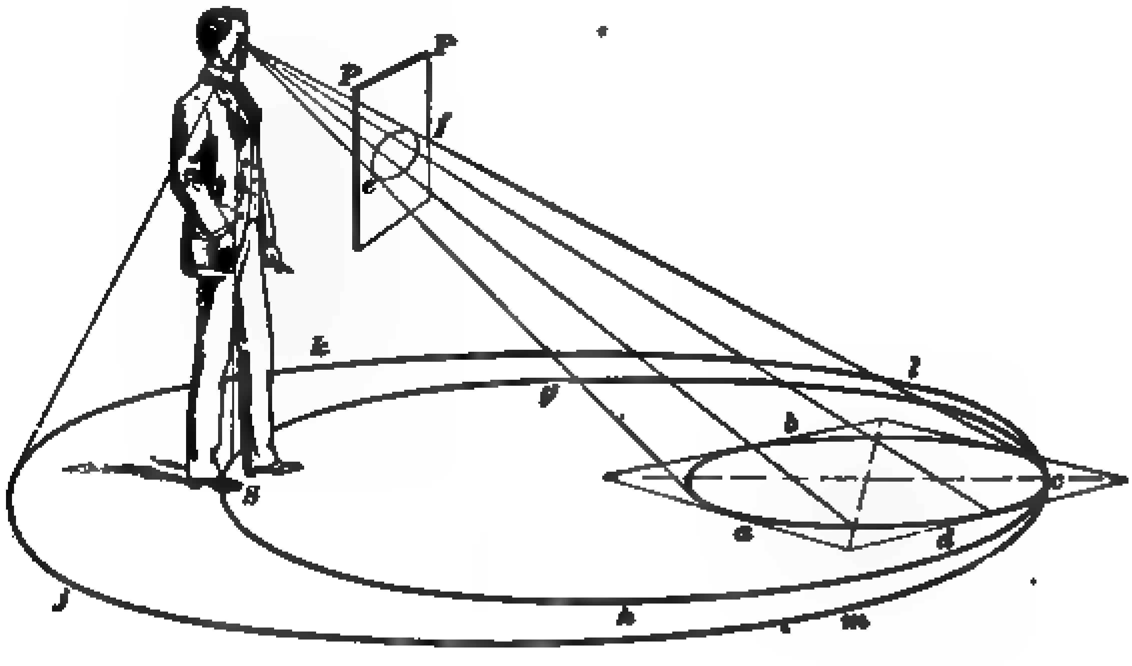


FIG. 37.

115. In Fig. 37, the spectator standing at S sees the circle $a\,b\,c\,d$ as an ellipse. However, he is standing on the edge of the circle $S\,g\,c\,h$, and any portion of a curve of that circle that appears on the picture plane $P\,P$ will be the arc of a parabola, and any portion of the arc of the circle $j\,k\,l\,m$, entirely within which he is standing, will appear as the arc of a hyperbola. The reason for this can be seen by a comparison with Fig. 38 (a), where $a\,b\,c$ is an oblique cone cut through by a perpendicular plane $P\,P$ that passes through both of its elements $a\,b$ and $a\,c$. The conic section produced by this is shown at (b) as an ellipse and corresponds to the conditions of the spectator in Fig. 37 viewing the circle $a\,b\,c\,d$.

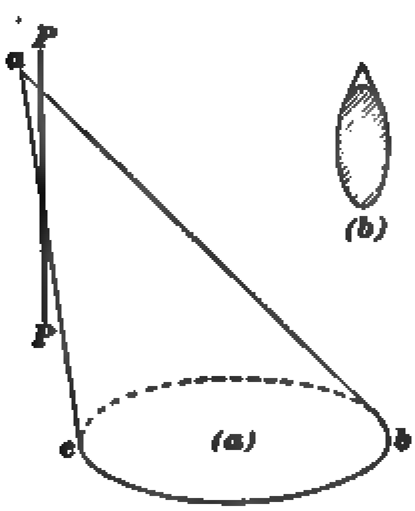


FIG. 38.

116. In Fig. 39 (a), the cone is shown corresponding to that one formed by the spectator standing on the edge of the

circle; we still have an oblique cone, and the plane of the picture passes through the base parallel to one of its sides thereby making the section a parabola, as shown at (*b*); and in Fig. 40 (*a*), the spectator stands within the cone itself, and the plane of the picture passes through the base of the cone and forms an hyperbola by its section, as shown at (*b*).

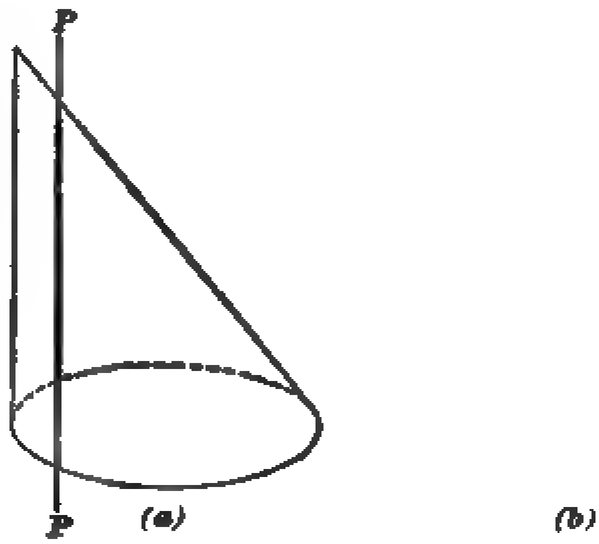


FIG. 39.

117. Projection of Circular Forms.—In projecting circular forms to the picture plane, it is always simplest to determine their form by means of relative points on straight lines. It has been shown how simple a matter it is to project a perspective view of a rectangle, and if we consider our circle as being enclosed in a square, as shown circumscribed in Fig. 37, it is a simple matter to draw that square in perspective and to note where the circumference of the circle intersects the diagonals of the square. These points and the points of tangency on the four sides of the square will give us eight points on the picture plane through which we can draw the ellipse representing the perspective of our circle.

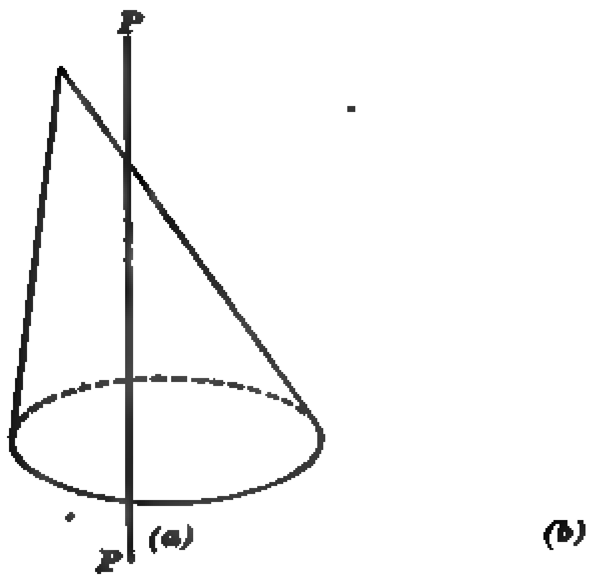


FIG. 40.

118. In Fig. 41, we have a horizon line HH with VL, V, VR, MR, and ML located on the principle of the

proportions of an octagon, as explained heretofore. At any

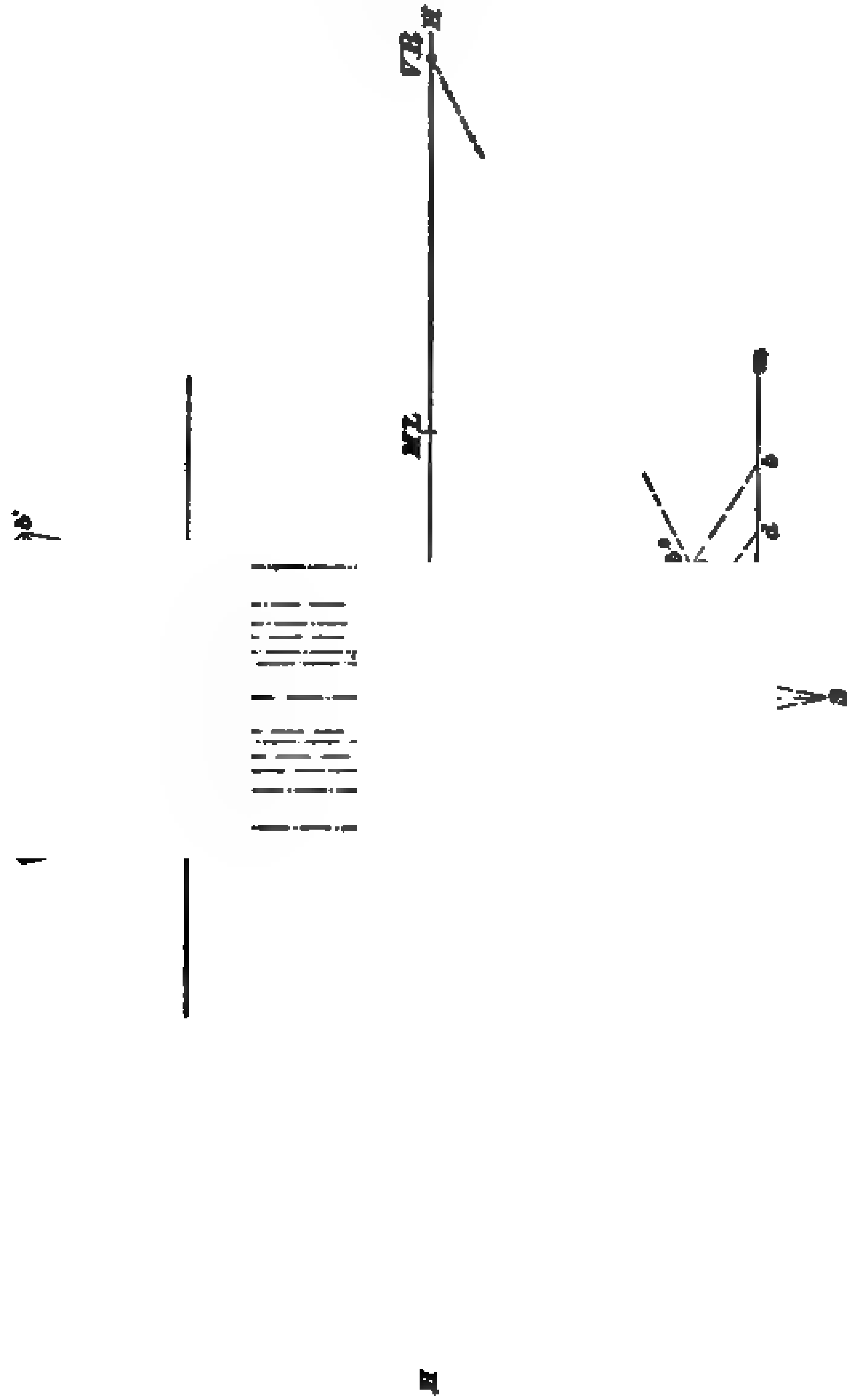


FIG. 41.

convenient point we draw our plane of measures *m m*, and

from a lay off $a\,b$ and $a\,c$ equal in length to the diameter of our circle, or in other words, equal to the sides of the square that encloses it. By laying off from a to d and from b to e a distance equal to one-half the diagonal of a square, we have, along the line $a\,b$, the division of one side of the square into points that, when connected, will form an octagon, as shown at $a'\,c'\,d'\,b'$, in the plan above, which plan, by the way, is not at all necessary in this case, as we are using the perspective plan.

119. From a, e, d, and b we now draw lines toward $M\,R$, our measuring point, until they intersect the line from a toward $V\,R$, thereby establishing points a, e^s, d^s, and b^s on the perspective side $a\,b^s$ that correspond to those in our plane of measures $m\,m$. Dividing the side $a\,c^s$, similarly, we can draw our octagon as follows: from e^s we draw through the corner of the rectangle a straight line parallel to the picture plane, and from d^s we draw a line toward the vanishing point of 45°, or, in other words, toward V. On the other two corners, after the measurements are laid out, similar points may be located and similar lines drawn. It is then a very simple matter to construct an ellipse within this perspective octagon that will be the perspective view of the circle as required.

120. Where the circle is not in a horizontal position the proceeding is exactly the same as shown in Fig. 42, where we have an arch whose plan, shown below, presents no data for the proportioning of the curve except its perspective diameter. However, in constructing the perspective elevation, above, we have, in perspective, a parallelogram $a\,b\,c\,d$ that is the perspective representation of the parallelogram $a'\,b'\,c'\,d'$ in the elevation to the left containing the semicircular arch of the opening.

121. The lines through the corners of this parallelogram that give us the octagon shape are located from the plan in precisely the same manner as before, the points being laid off on the measuring line $m\,m$ and projected to the line $b\,c$

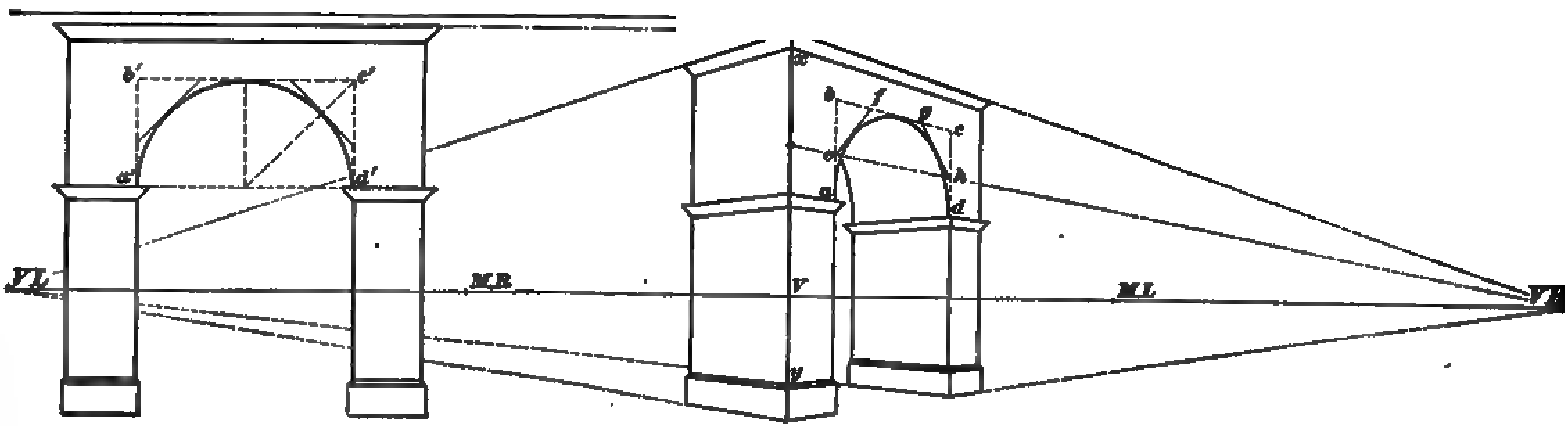


FIG. 42.

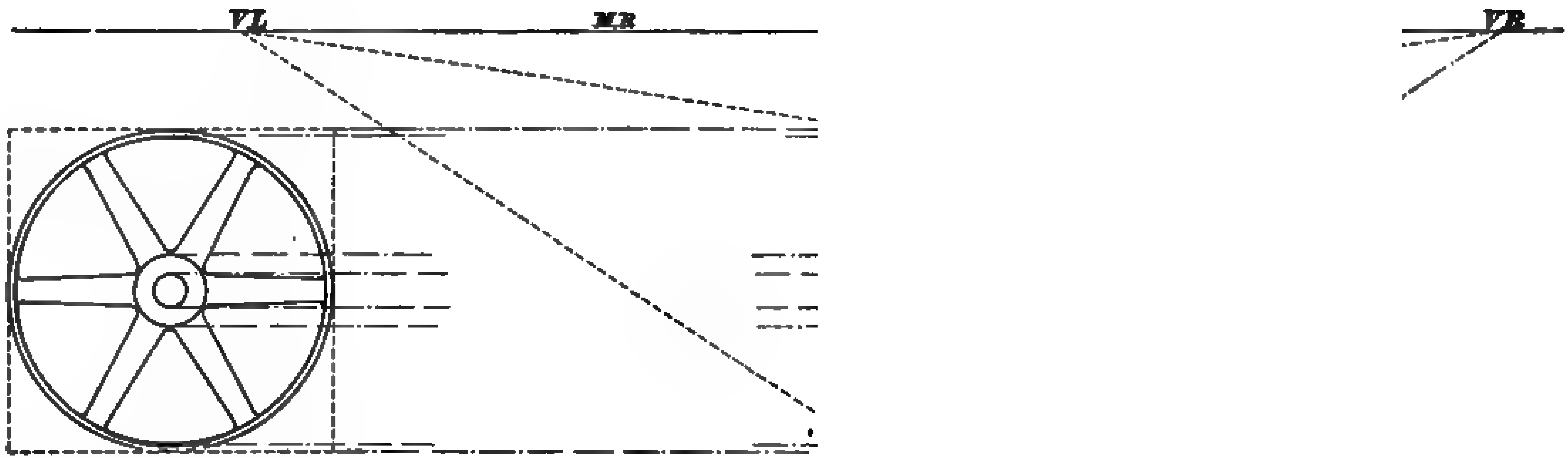


FIG. 42.

directly from the perspective plan. The point *e* on the side *a b* of the rectangle in the perspective elevation may be located by setting off its true height on the corner of the arch *x y*, which is in the plane of measures, and projecting it to its true place by a line toward *V R*, as shown; or, after locating *f*, a line may be drawn through *f* toward *V b''*—the vanishing point of lines inclined at an angle of 45° and parallel to *S*–*V R*. The side *g h* of the octagon can then be simply drawn toward *V s''*, or the points may be projected from the corner *x y* of the arch and drawn in as before suggested, the construction of the ellipse after the octagon is formed being simply a matter of freehand sketching.

122. In Fig. 43, we have an ordinary cast-iron pulley wheel, the perspective rendering of which consists almost entirely of ellipses. In this case, as before, we simply considered the circle representing the rim of the wheel enclosed in a rectangle or octagon, as shown at *a b c d*. The perspective of this rectangle appears in the form of a rectangular box, inasmuch as the wheel has considerable thickness, and we find ourselves drawing two ellipses as the rim—one, in the front of the box, and the other in the bottom of it. The hub of the wheel in the middle is constructed in a smaller rectangle in the same manner. The lines at the top and bottom of the wheel that connect the ellipses and represent the thickness or breadth of the rim are drawn toward *V L*, as shown.

123. In Fig. 44, we have another wheel, the rim of which is much narrower than the last one, and for all practical purposes the two ellipses that form its rim might be drawn alike. The points on the interior of the rim where the spokes are inserted can be projected from the elevation and carefully drawn within the ellipse after the hub has been located according to lines projected from the plan.

124. In drawing circles in perspective the student will meet with no serious difficulty if he always considers them as polygons having an infinite number of sides drawn within

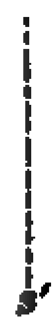


FIG. 44.

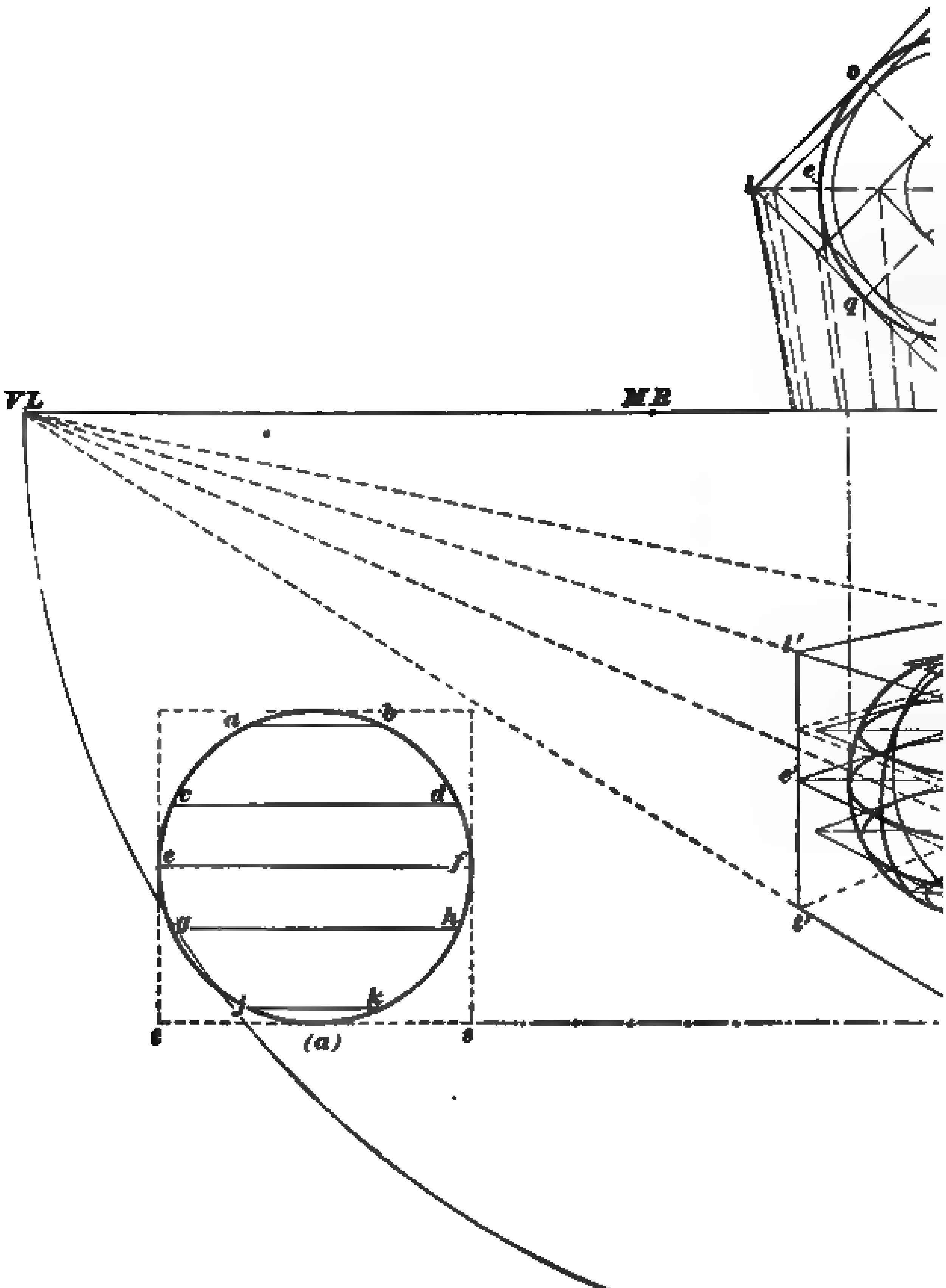
a rectangle. Methods have been shown by which a rectangular surface, no matter what may be its inclination or position, may be easily drawn in perspective, and in the preceding problems the plans of the houses, the perspective elevations of their sides, the surfaces of their roofs, etc. all represent rectangular surfaces in different positions and at different inclinations.

125. Any square can be drawn in a similar position, and when once projected in perspective it is a simple matter to convert the square into an octagon by locating on its sides the points in perspective where the extra sides of the octagon will intersect. These sides may be again divided into four parts, and from the extreme part on each side, lines may be drawn converting the perspective of the octagon into a figure having sixteen sides, which in the majority of cases will be so near a circle that it will require simply a gentle curving of the lines in order to produce the ellipse that represents the circle in perspective.

126. Laying Out Circles.—It is frequently convenient to lay out these circles on a separate piece of paper, and having perfected the ellipse that represents one circle in perspective, to trace it off and transfer it to the drawing where it is required. For instance, in Fig. 45, we have what might appear to be a globular cage or basket composed of eight circles sprung together in zones. To lay out all the construction lines necessary to draw this figure would confuse the drawing very materially, therefore it is more convenient to lay over the perspective rendering a piece of paper and to draw separately thereon each ring or ellipse; having perfected which, it may be traced and transferred to the final drawing, in order to produce the finished result.

127. Fig. 45 consists of three vertical circles and five horizontal circles, the vertical circles all being the same size but the horizontal circles being of three different sizes according to their positions on the sphere.

At (*a*) is shown the elevation of one of these vertical



VL
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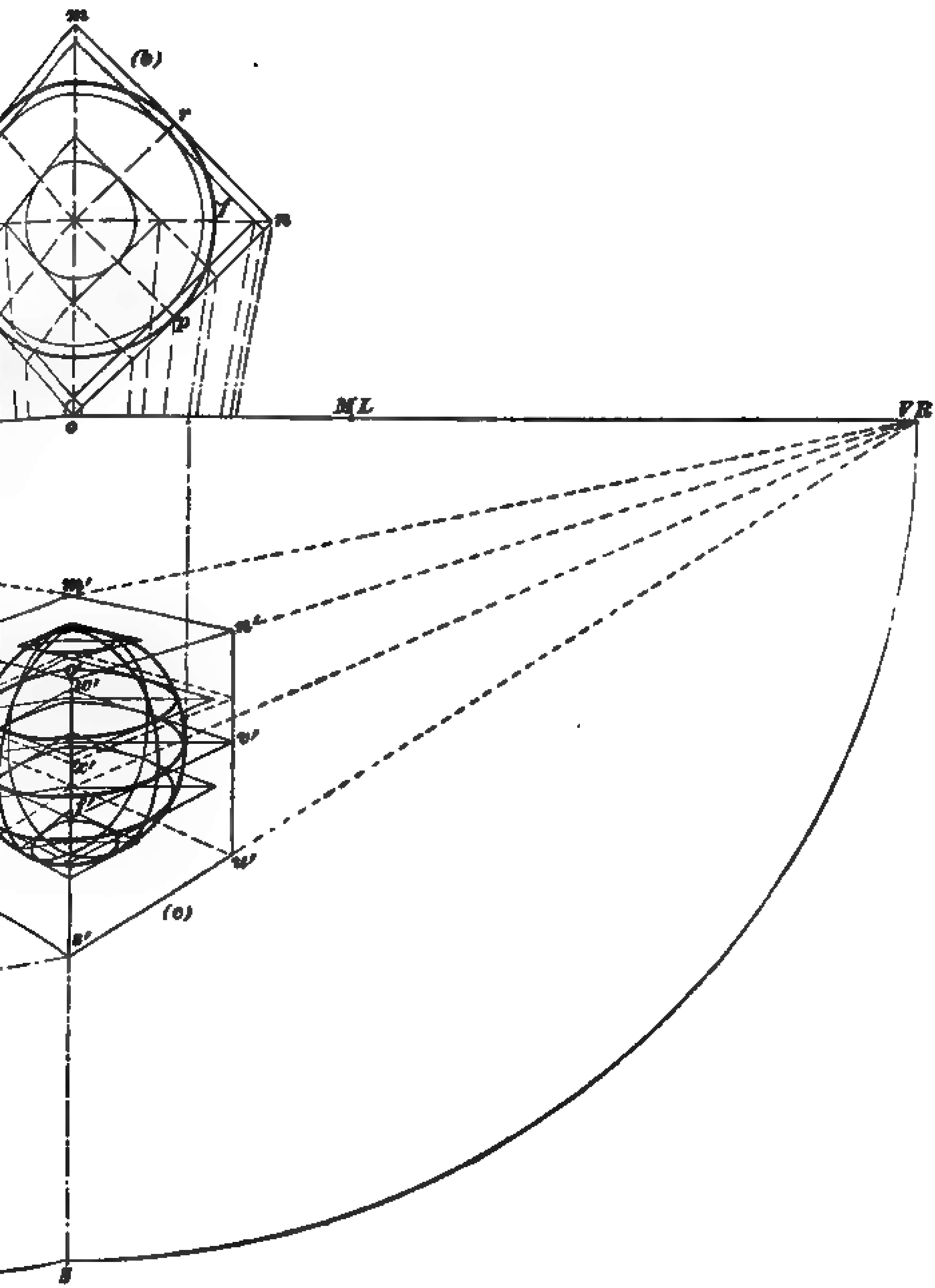


FIG. 42.

circles enclosed within the dotted square, on which the positions of the horizontal circles are also shown by means of the lines *a b*, *c d*, *e f*, etc. In the plan (*b*) the central horizontal circle is shown by the heavy line, and also its enclosing square *l m n o*. The diagonal of this square *l n* corresponds, in position, to one of the vertical circles, and the other two vertical circles are located according to the positions indicated by the broken lines *o p* and *q r*.

In order to represent this figure, we first draw the cube $l' m' n' u' s' t'$, and on its edge $o' s'$ locate the point f' half way between o' and s'. $f' e' w' v'$ will then be a square containing the largest horizontal circle *e f*. The other two circles, above and below, are then located in smaller squares that are drawn in their relative positions. To draw these, it is convenient at first to locate a large square immediately over $f' e' w' v'$, the corner of which touches the edge of the cube $o's'$ at x', a point on a level with the circle *c d*, as shown in the elevation (*a*). The smaller square containing the circle *c d* may be then drawn, as shown at (*c*), and the other circles located in a similar manner in their relative positions. In doing this, the perspective of the squares containing the ellipses are all that need be shown on the original drawing. These can then be redrawn on a separate piece of paper, and the ellipse sketched in, and when perfect traced in its proper place upon the perspective drawing, as shown in Fig. 45.

PERSPECTIVE DRAWING.

INTRODUCTION.

1. The following exercises in perspective drawing are intended to familiarize the student with the general subject of perspective and include all problems likely to occur in ordinary perspective sketching. The examples are arranged so as to put into practice, successively, the different rules and principles, and should be studied with the greatest care by the student in order that they may be clearly impressed on his mind, as problems of measurement and proportion explained on one plate will not be explained again on the advanced plates.

In this work, both instrumental and freehand drawing will be required, although on the first plates the work will be almost entirely instrumental. The greatest care in computing distances must be exercised, as otherwise badly proportioned drawings will result.

DRAWING PLATE, TITLE: ELEMENTARY PRINCIPLES.

2. In order that the student may properly understand the application of all details explained up to the present time, he will execute a drawing plate as follows:

After drawing the border line 13 in. × 17 in., as in previous work, he will draw, $6\frac{1}{4}$ inches above the lower border line, a picture plane PP, as shown, with his vanishing points

vl and *vr* exactly 12 inches apart. He will then draw above the picture plane, on a scale of 1½ inches to the foot, the plan of a bookcase, as shown at *a b c d*, the sides *a b* and *c d* of which are 1 foot long and incline 60° with the picture plane, the sides *a d* and *b c* are 2 feet long and incline 30° with the picture plane, and the point *a* is 3½ inches to the right of *v l*. The books, shown in position in the plan of the case, are 2 inches in thickness on the lower shelf and are indicated by the longer lines of division, and 1½ inches in thickness on the upper shelf and are indicated by the shorter lines of division. The sides and back of the case are 1 inch in thickness.

On a horizontal line 9¾ inches above the lower border line, draw the elevations of the bookcase between the center line of the drawing plate and the right-hand border line, as shown. It will be observed that the top of the case inclines backwards in order to make a reading shelf, so to speak, on which books may be placed; this is the only detail of importance for which we need the end elevation. The dimensions of the parts are given on these elevations, and the student has only to draw according to the sizes marked.

3. The student will now draw a semicircle with *v l* and *v r* at the extremities of its diameter and from *v l* draw a line parallel with *a b*, the end of the bookcase in the plan, and from *v r* draw a line parallel with the side *a d* of the bookcase plan. These lines will intersect at *S*. From the corners of the bookcase and the points of division between the books in the lower shelf in the plan, lines may be drawn converging toward *S* and marking points on the picture plane *P P* that determine the relative width of these details in perspective. In doing this, it is well to put a small needle through *S* and to rest the triangle or straightedge against it, using a very sharp pencil to transfer the measurements and to mark the lines as they cross the picture plane. The dotted line around the bookcase indicates the outline of the reading shelf on top of the case and projects 1 inch beyond all sides, except the back, and extends below the

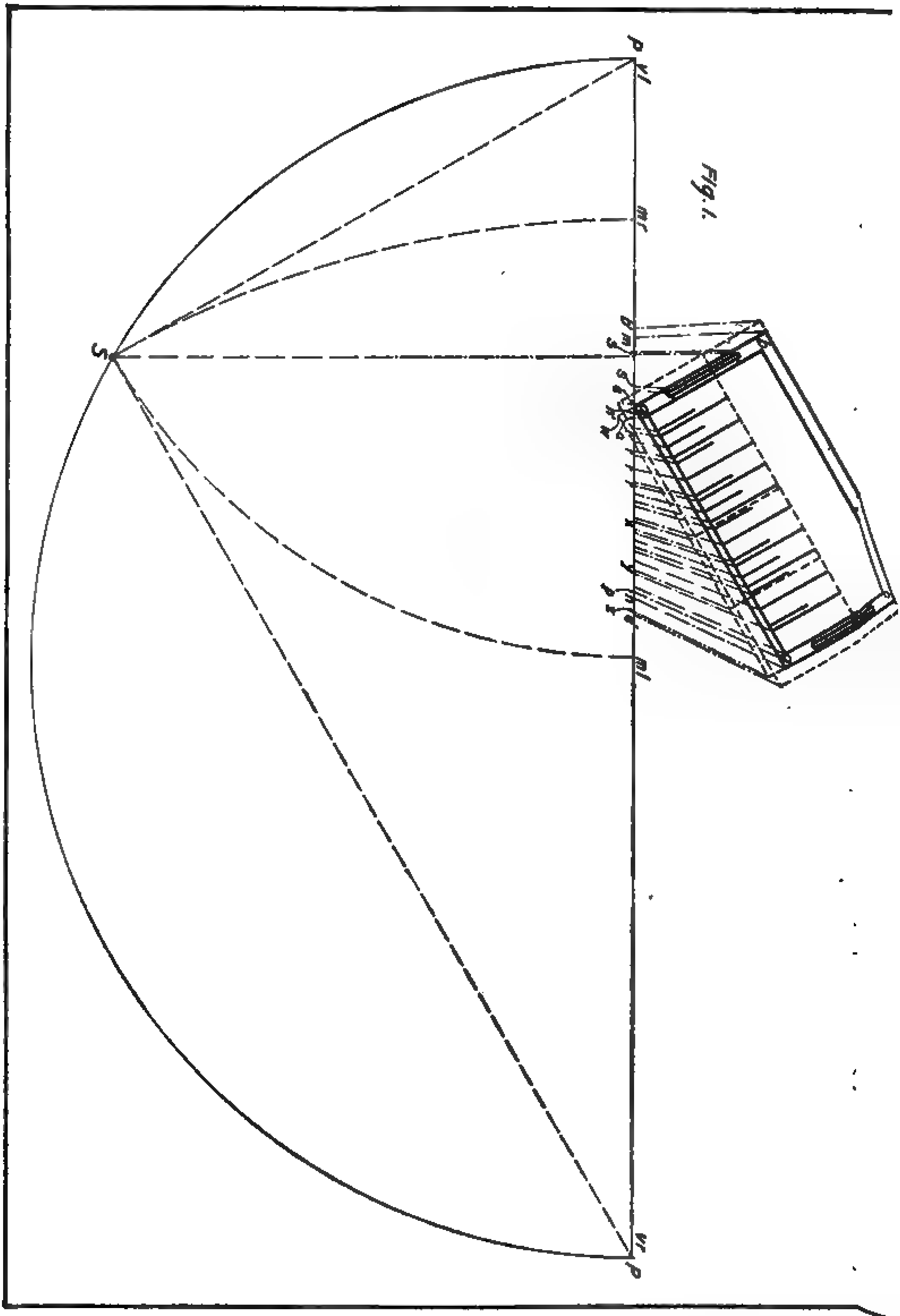


Fig. 1.

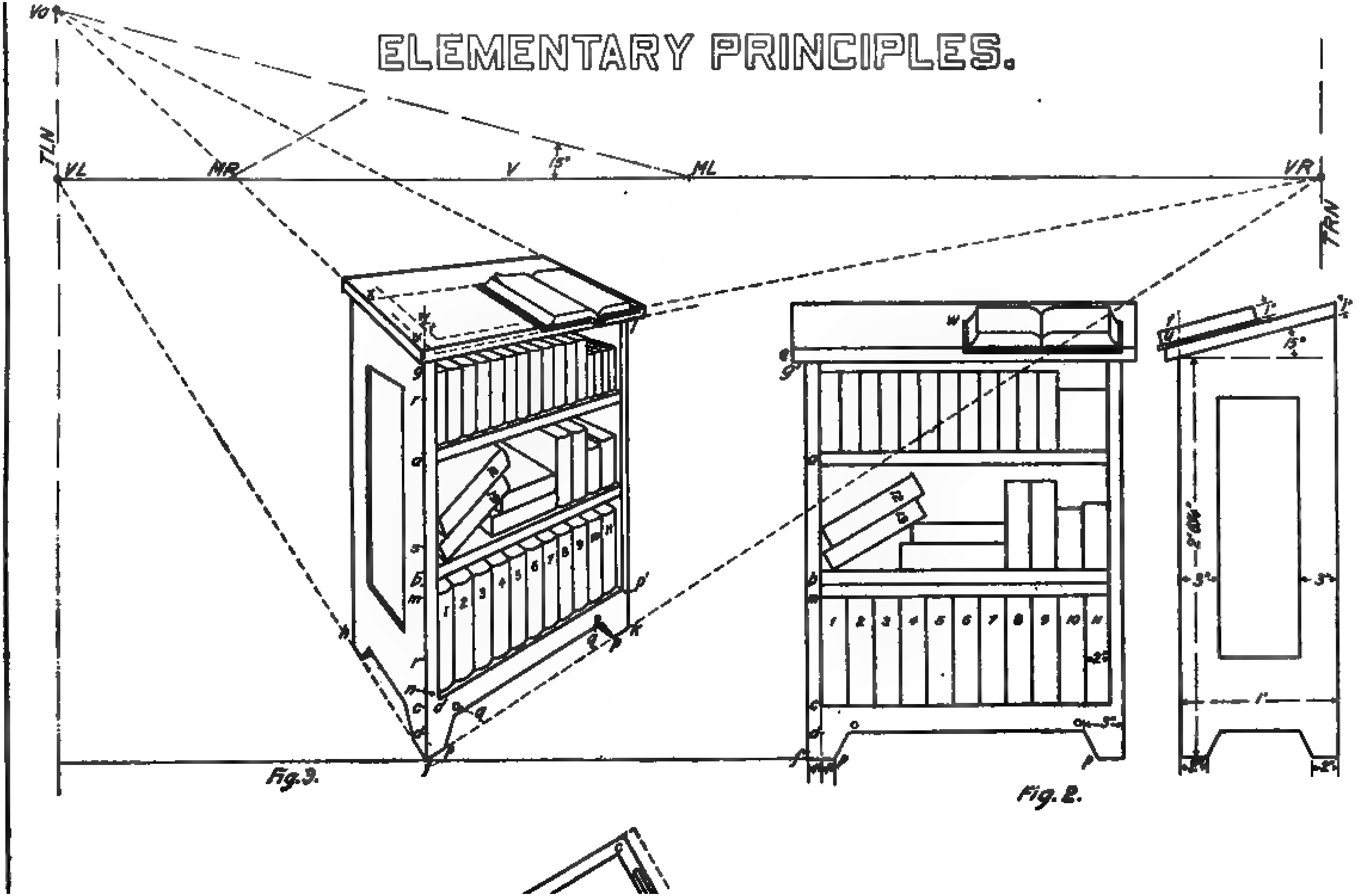


Fig. 3.

Fig. 2.

picture plane; for that reason, the line from S through the corner of the plan of this reading shelf is projected *back* to the picture plane and has its point of intersection at e, just to the left of a.

Draw a horizon line, 15½ inches above the lower border line, the ends VL and VR of which are to be directly above vl and vr of the plan, and through VL and VR draw vertical lines TLN and TRN, as shown. From the points where lines drawn from the principal details of the plan of the bookcase cross the picture plane, erect vertical lines, establishing points in the perspective elevation as follows: First, directly over a in the plan, Fig. 1, draw fg equal to, and in line with $f'g'$ in the elevation in Fig. 2; then from f and g draw lines converging toward VL and VR until these lines intersect with kj and kl (kj and kl being vertical lines drawn directly over m and n of Fig. 1, where the lines toward S from b and d, the corners of the bookcase, intersect with the picture plane).

The points o and p may then be projected upwards, from Fig. 1, to locate the thickness of the wood on the ends of the bookcase, as shown in Fig. 3 at o' and p'. The shelves and top and bottom may be drawn as follows: From a and b in Fig. 2, project across the thickness of the shelves and mark this thickness on the line fg, as shown at a and b in Fig. 3, and at the same time mark, in Fig. 3, the points c and d, which locate the height of the lower shelf and the bottom of the front of the case, as shown by the points c and d in Fig. 2.

From the points at a and b draw lines toward VR to the opposite side of the bookcase, thus locating the shelves in front, and from c draw a single line locating the height of the bottom shelf. The underside of the front will not be put in at present, but will be left until the books have been located.

4. Over the point e, in Fig. 1, draw a short vertical line representing the corner of the top of the bookcase and limit the line to the thickness of the top, as shown at e in Fig. 2.

The line *gl* may now be drawn until it reaches another short perpendicular line drawn directly over *e'* in Fig. 1, thus marking the front edge of the top of the bookcase. Now, from *vl* in Fig. 1 lay off, to the right, the distance *vl–S*, marking the point *ml* on the picture plane *PP*. Directly over this, on the horizon line in Fig. 3, mark the point *ML*, and from *ML* upwards and toward the left draw a line at an angle of 15° until it intersects *TLN* at *Va*, this being the angle of the slant of the top of the case, as shown by the end elevation in Fig. 2.

From the corner drawn at *g*, draw lines toward *Va* to represent the thickness of the slanting top of the desk and end these lines with a short perpendicular piece at *j* drawn directly over the point *b'* in the plan, this being the edge of the shelf. The line of the back of the shelf from *j* toward *VR* may now be drawn until it intersects with the line drawn from the end of the shelf at *l* to the vanishing point *Va*, thus ignoring the outline of the book that is lying there, but which will be considered later. This completes the general outline of the bookcase and we may now proceed to fill in the details of the books.

From the points *r* on the picture plane *PP* in Fig. 1, where the lines drawn from the corners of the books in the lower shelf, toward *S*, intersect, erect perpendicular lines in the lower division of the bookcase in Fig. 3, being careful to have each line over its respective point in the plan. Limit the height of the books in Fig. 3 between lines drawn toward *VR* from *m* and *n*, *m* being located exactly opposite *m* in Fig. 2, and *n* being located on a line from *o'* to *VL*, and exactly over the point *n'* in the plan where a line drawn from the corner of the first book, toward *S*, would intersect the picture plane.

5. The top edges of the books may now be represented by single lines toward *VL*, and the slightly rounded backs of the tops and bottoms may be sketched in freehand, as shown. It will now be well to project the height of the numbers on the backs of the volumes in Fig. 2 to the edge

of the case *fg* in Fig. 3 and then to locate on the back of each volume in Fig. 3 its proper number, in order that references to them hereafter may be easily understood. It will now be noticed that the points *q* in Fig. 3 are directly under the inside edges of Volumes *1* and *11*, and that the points *p* are about under the center of these same volumes. These points, being projected downwards, will enable us to locate the limits of the line *o o* and also the lengths *f p* and *p k*. From *p*, a line is drawn toward *V L*, representing the thickness of the right foot of the case.

6. In order to locate the feet on the left end of the case, it will be necessary to lay off their width, both top and bottom, in the plan and to project lines therefrom to the station point *S*, to get the intersection with the picture plane. The lines marking the width of the tops of these are shown at *s* in the plan, and correspond exactly to the widths of the styles each side of the panel in the end of the case. These points can be located on a line drawn from *d* toward *V L*, and the line showing the 2-inch width of the bottom of the feet can be projected from the plan and located on the line from *f* toward *V L*, thus completing the general end view of the bookcase, except the panel and the thickness of the back foot, which is indicated simply by drawing a short line toward *V R* until it is stopped by the full line in the direction from *d* to *V L*, Fig. 3.

7. The height of the panel should now be transferred straight across from the end view in Fig. 2 and marked on the corner of the bookcase in points *r*, *r*, Fig. 3; from these points, lines drawn toward *V L*, and limited between the vertical lines drawn over the corresponding points in the plan, will outline the top and bottom of the panel. The sides of the panel may then be drawn directly over the points *s*. *s* of the plan, Fig. 1.

The thickness, or amount of the rebate of the panel may be projected from the angle in the end of the case, if desirable, but it will be found perfectly satisfactory to estimate

this distance by the eye and to draw a vertical line representing the thickness of the back style, and a line from it, in the direction of *VL*, to indicate the thickness of the lower rail.

8. It will be observed on looking at Fig. 2 that the lower of the horizontal books lying in the middle of the second shelf has its ends directly over the joints between Volumes *3* and *4*, and *7* and *8* of the lower shelf. Therefore, by projecting these lines directly upwards in Fig. 3, we draw the ends of this book as a straight line at first between the divisions of Volumes *3* and *4*, and *7* and *8*; and the end of the upper of the horizontal volumes in Fig. 3, over the center of Volume *4*, and the other end the same as the lower volume. Lines drawn toward *VR* between the ends of the volume so located indicate the backs of these books on the second shelf.

9. In order to locate the inclined volumes shown to the left of the horizontal ones in Fig. 2, it will first be necessary to locate, in Fig. 3, the corner of the volume marked *13* in Fig. 2. This, according to scale, is exactly 1 inch within the bookcase and corresponds with the lower edge of the foot on the left end of the elevation; or, in other words, it is directly over the point *p* in Fig. 3. This point being located in the elevation, the other corner of the book against the end of the case is projected straight across from Fig. 2 to Fig. 3 and is located at *s* on the corner. A line drawn from *s*, toward *VR*, will locate the position of the corner of the book on the inside of the case, and a line drawn from the last point located, to the point over *p* previously located, will be the direction of the end of this book. As a matter of fact, this book being inclined at an angle of 30° with the book shelf, the end just drawn could be projected toward a vanishing point under *VR* and 60° below *MR*, but as this point would be too far below to locate conveniently on the board, another method is adopted.

10. The other inclination of the books, however, will be projected to its vanishing point at *Vb*. First, lay out to the

left of *v r* the distance *v r*–*S* in Fig. 1, and mark this point *m r*. Then, directly over this, locate the point *M R* in Fig. 3, and from *M R*, at an angle of 30°, upwards and to the right, draw a line until it intersects with the vertical plane *T R N* drawn through *V R*. This, then, will be the vanishing point of lines inclined above the horizon at an angle of 30° toward which the sides of the inclined books in Fig. 3 will vanish.

11. The lengths of these books may be drawn by comparing them with the books in the shelf below; it will be found that their right-hand ends are directly over the joint between *4* and *5*. The upper ends of the books may be drawn parallel with the lower ends, although this is not their exact direction but in a drawing of this character it is sufficiently accurate for general purposes. Lines from the corners of the books, where they are exposed, may be drawn toward *V L*, thus indicating the complete outline of the books in plan.

The other four books at the end of the case are directly over Volumes *8*, *9*, *10*, and *11* of the shelf below, and their height may be projected across from Fig. 2 and marked on the line *f g* of Fig. 3. The line may then be projected toward *V R* until it intersects with the vertical divisions between these books. Lines indicating the tops of the books can be drawn toward *V L*. This will complete the representation of the books in the second shelf.

12. To draw the books in the upper shelf most accurately, it will be desirable to make another plan and pin it over the plan below in order that there may be no confusion of lines; but the same thing may be accomplished by careful work if lines are drawn from the ends of the short lines of division shown on the plan, toward *S*, marking the widths of the books in the upper shelf, and then vertical lines drawn in Fig. 3, limited, as before, by lines drawn toward *V R*, from points located on *f g* that limit the height of these books, as shown in the top shelf of Fig. 2. These are all

drawn precisely as other books have been drawn on this plate and need no further explanation.

13. All the details have now been completed except the drawing of the open book that lies on the top of the bookcase. The outline and center fold of this book should be drawn carefully in the plan below, Fig. 1, as shown by the heavy dotted lines. It will be observed by comparing the plan in Fig. 1 and elevations in Fig. 3, that the front edge of the book projects over the desk somewhat and that the right-hand end is about even with the vertical side of the case. Lines drawn from the three principal points on the front of the book, as shown in the plan, locate, by their intersection with the picture plane, the points x, y, and z over which the corners and center of the front edge of the book can be located in Fig. 3.

14. The line fg of Fig. 3 should now be prolonged, somewhat, above g and the front edge of the bookcase in the side elevation of Fig. 2 carried up through the thickness of the book. The point where the top of the book leaves cross the line of the front edge of the end elevation of the bookcase in Fig. 2, marked t, may now be projected across until it intersects with the corner of the bookcase in Fig. 3, and there marked t. Through t, toward Va, a light line should be drawn and also through the point u, which is projected from the point u in Fig. 2. This shows the thickness that the book would appear if drawn at the end of the bookcase next the picture plane.

15. It will now be necessary to draw in Fig. 1 a line parallel with the front of the bookcase and in continuation of the front edge of the book until it intersects the line $b\,a$, prolonged, at w. The point w must be projected back to the picture plane PP and there located. For all practical purposes this point may be considered the same as the inside line of the edge of the bookcase o. If, therefore, we can mark, in Fig. 3, the point where the inside line of the nearest edge of the bookcase would cross the line drawn,

from u toward Va, we have a point representing the projection of the book over the edge of the case, and from this point we can draw a line toward VR through the front and lower edge of the book cover. Now the line directly over x in Fig. 1 limits the left-hand edge of this cover, and from it we may draw the left-hand edge toward Va, as the book inclines upwards with the top of the desk. The center point y in the plan and the right-hand edge z in the plan may now be projected upwards, and the line in Fig. 3 drawn through the point t may be continued downwards until it intersects with the line over the inside of the bookcase, and a line from there drawn toward VR, indicating the thickness of the book.

The leaves may be rounded in, freehand, toward the center as projected up from the plan below, and the concave edges of the outer leaves in front may also be sketched freehand. Lines drawn from the corners and convex side of the center, toward Va, will indicate, in general, all the details of the book, except the back, and this may be located by drawing across the shelf, in Fig. 1, a line to the end of the case and locating this point on the picture plane by means of a line toward S. This point will fall practically at s and a point over s, in Fig. 3, will fall at x. A line drawn from x toward VR will limit the top of the back of the book, and the top of the back of the leaves may be drawn proportionately above it, by the eye.

All these details are not mathematically accurate, as to position and location, as we will see hereafter, but in working on this scale there will be no appreciable difference after going to the trouble and complications necessary to get the exactitude of perfection.

Having completed the perspective drawing, Fig. 3, the student will erase all construction lines, leaving only the outline drawing of the bookcase and its books, and the horizon and the letters indicating the vanishing points, but Figs. 1 and 2 may be inked in, as shown.

16. It will be observed that the perspective rendering of the books places them slightly within the edge of the

shelf, and the student in drawing his plate will show this recession, although no dimensions have been given for it; it simply requires that in inking in his drawing after all his pencil work has been completed, he shall set back the lower edges of the books sufficiently to show this line.

After inking in the drawing and the border line, the student will place the title in its proper position, letter his name neatly in the lower right-hand corner and the date in the lower left-hand corner, and send the plate to the Schools for correction.

DRAWING PLATE, TITLE: 45-DEGREE PERSPECTIVE.

17. In the execution of this drawing plate it will be necessary to make several practical sketches on separate pieces of paper before the final plate is attempted. Start with the plan of the small library building shown in Fig. 1, and its front and end elevation shown in Fig. 2. It is desired to make a perspective drawing of this simple structure as it would

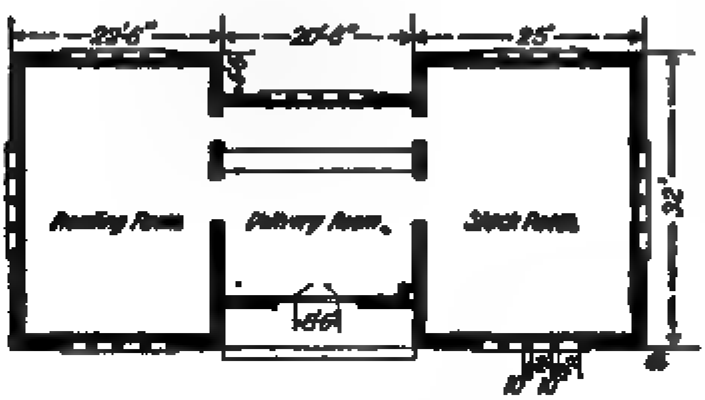


FIG. 1.

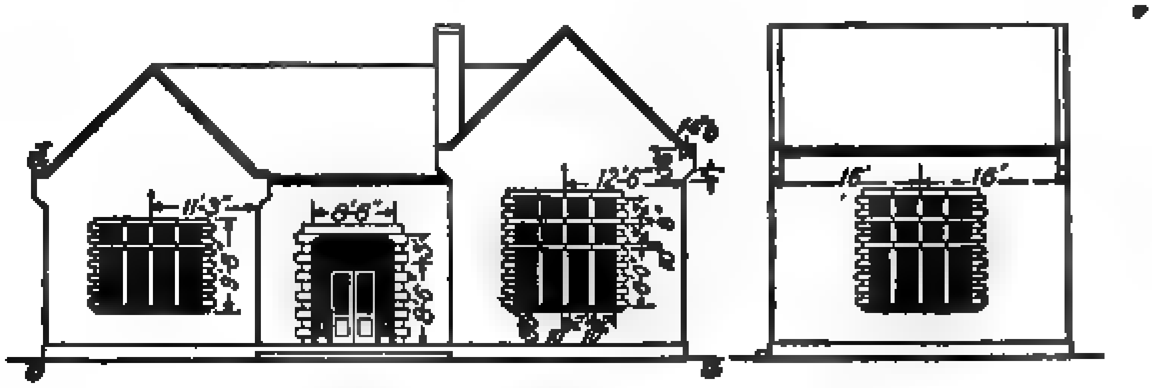


FIG. 2.

appear from a point about 48 feet distant and 15 feet to the left of the corner of the building marked *a*.

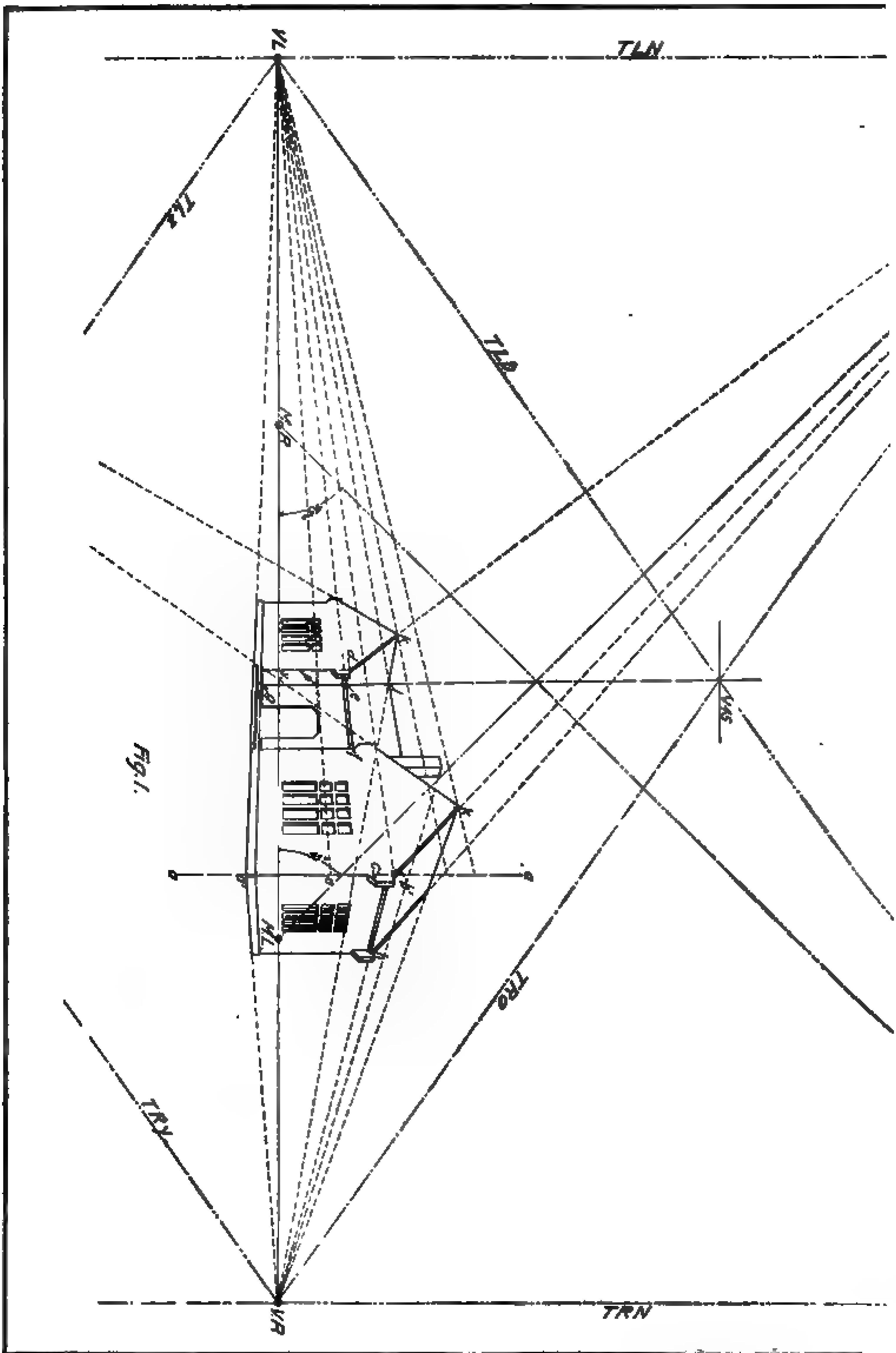


Fig. 1.

45 DEGREE PERSPECTIVE.

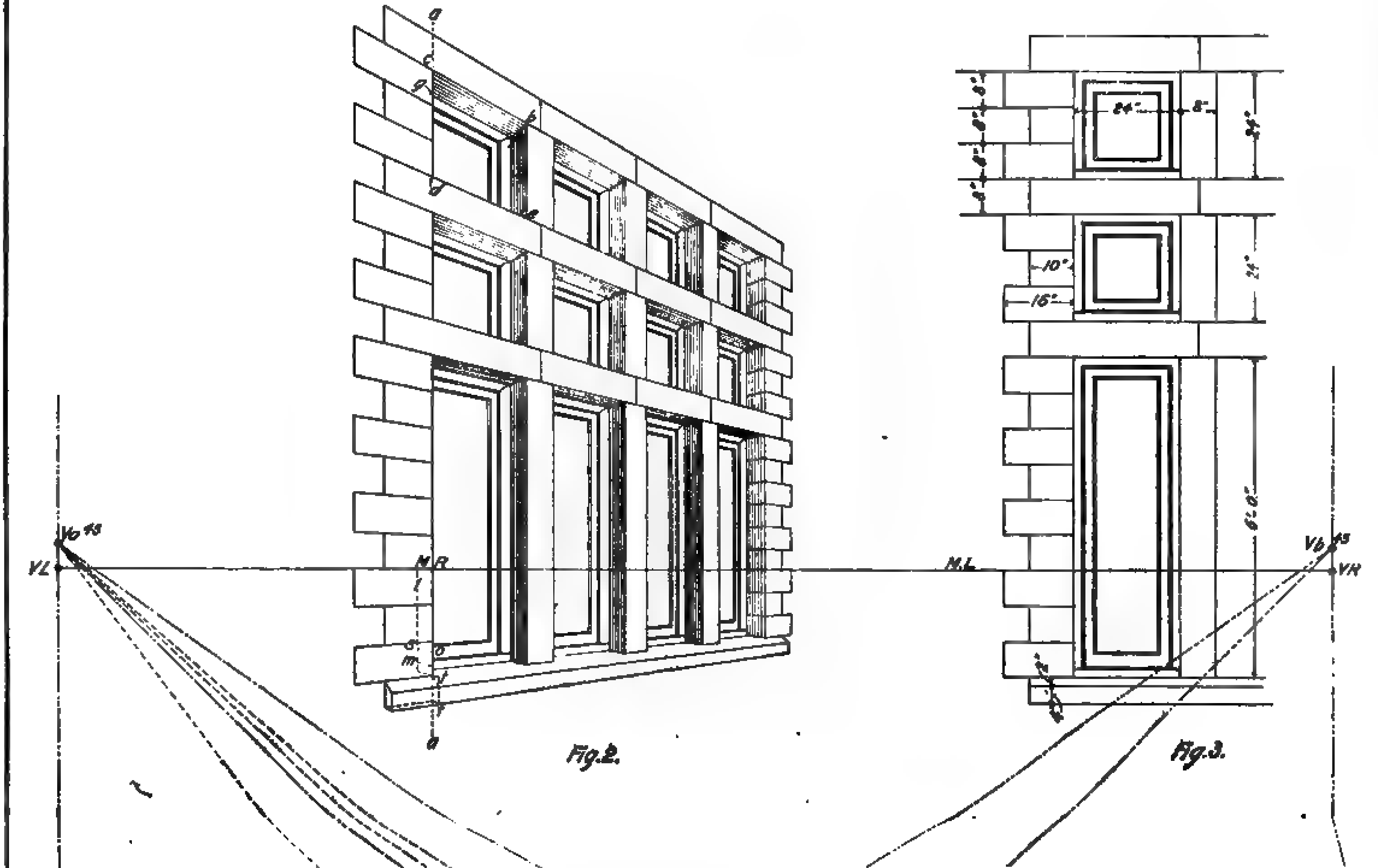


Fig. 2.

Fig. 3.

18. After drawing the border line, enclosing a space 13 in. × 17 in., cover the upper half of the plate with another piece of drawing paper and on it draw the plan and locate the vanishing points, measuring points, etc. as shown in Fig. 3. Draw the line *P P* at any convenient point 3 or more inches below the top of the paper, and in the center *c* of this line locate the vanishing point of 45°, as shown at *v'*. With *c* as a center, and a radius of 6 inches, describe the semicircle *P S P*. This will locate the vanishing points *v l* and *v r*, 12 inches apart, and the station point *S* in the circumference of the semicircle at the intersection of two lines drawn at angles of 45° with the picture plane from *v l* and *v r*. With *v l* and *v r* as centers, and *v l*–*S* or *v r*–*S* as a radius, strike two arcs from *v r* and *v l*, marking at *m r* and *m l* the measuring points on the picture plane.

19. Above this picture plane, and in contact with it, draw the plan of the building, according to the dimensions shown in Fig. 1, locating the point *a* 30 feet to the right of *c* on a scale of $\frac{1}{16}$ inch to the foot. The side of the building *a b* is to be inclined with the horizon line at an angle of 45°, in order that it may be parallel with *S*–*v l*, the line from the station point to the left vanishing point. All the details of the plan on the sides *a b* and *a c* being drawn in place, as shown in Fig. 3, lines may be drawn from the principal features on these sides toward the station point *S*, and points marked where these lines intersect the picture plane *P P*. Having drawn all these lines and located the points, the student may proceed to draw Fig. 1, of the drawing plate.

Draw a horizontal line, 2½ inches above the lower border line, through the plate, 12 inches in length, marking the extremities *V L* and *V R*, as shown in Fig. 1, of the drawing plate. Then locate *M R*, *M L*, and *V* directly under *m r*, *m l*, and *v* of the plan. Draw a perpendicular line from the point *a* in the plan above through the horizon line just located in Fig. 1, of the drawing plate. This line will be the line of measures on which must be laid off the vertical measurements of the various portions of the building at a scale

of $\frac{1}{16}$ inch to the foot. The lines of the other corners of the

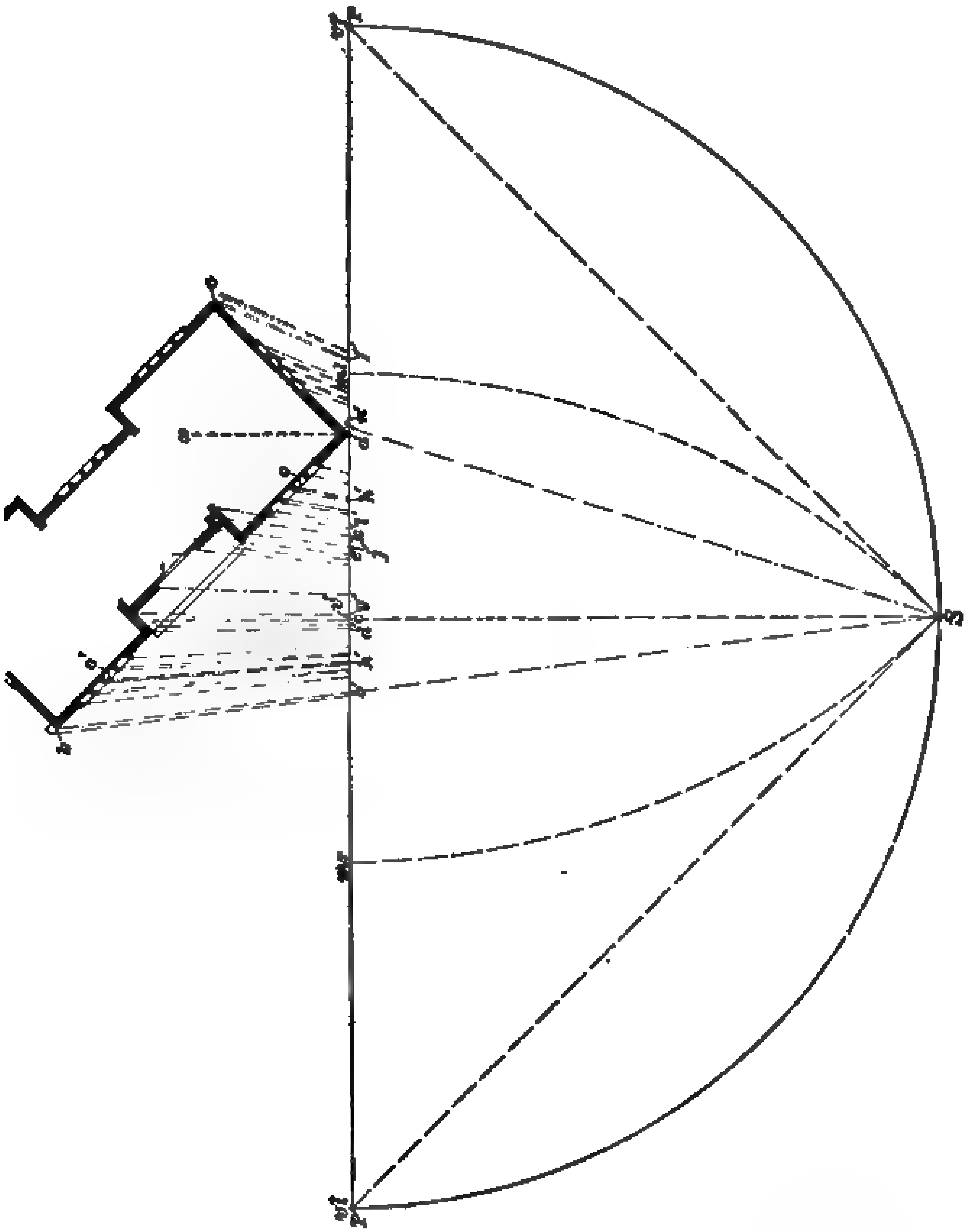


FIG. 4

house, as projected in the plan above, may now be indicated by means of indefinite lines drawn across the horizon line

directly under these points, as projected against the picture plane at b', d', e', f', etc. in Fig. 3.

20. On the measuring line $a\,a$ lay off, in Fig. 1, of the drawing plate, a distance of 5 feet below the horizon line, as shown at a', which will mark the ground line of the corner of the building. Then, from a' to b' lay off the height of the building to the slant of the roof, equal to $a\,b$ in Fig. 2. From a' and b' draw lines converging toward VL and VR, and the points where these lines intersect the vertical lines drawn under b' and f' of the plan above, as shown in Fig. 3, will mark the heights of these corners of the building. From a' lay off the distance $a'\,c'$ equal to the height of the farther eaves, as shown at $c\,d$ in Fig. 2. From c' of the drawing plate toward VL draw a line marking the height of the eaves on the farther gable, where this line intersects the vertical lines under b' and d' of the plan.

21. The line of the inner angle in the recessed front, as indicated at g' on the picture plane in Fig. 3, may be drawn through the horizon line in Fig. 1, of the drawing plate, as shown at $l\,g$, and the eave line drawn from d toward VR until it intersects with $l\,g$ at e, then the eave line of the recessed portion of the roof may be drawn from e to f on a line diverging from VL.

The slant of the gables of this roof is 45°, therefore, from MR and ML, at angles of 45°, draw lines indefinitely to the right and left, as shown in Fig. 1, of the drawing plate. From VL and VR draw vertical lines until they intersect with these 45° lines, thereby locating the vanishing points Va'' and Vb'', these being the vanishing points of all lines that extend from the station point upwards and to the left and right at angles of 45° both with the ground and the line of direction, and of all lines parallel to them; in other words, the vanishing point of all lines parallel with the sides of the building $a\,b$ and $a\,c$, in Fig. 3, but extended upwards at an angle of 45°. Similar lines drawn at angles of 45° from MR and ML downwards and to the right and left, will

locate the vanishing points of lines at an angle of 45° with the ground line but extended downwards to the right and left and parallel to the house lines.

22. From b', in Fig. 1, draw a line toward Va, and from h and d similar lines toward the same vanishing point. These lines show the inclinations of the gables on the near side, and the inclinations of the gables on the other side can be drawn from vanishing points Vy and Vz located the same distance below the horizon line that Va and Vb are above. As these points will probably be inaccessible to the student, owing to the smallness of his drawing board, we will accept the alternative method of drawing them.

23. From the points o and o' in Fig. 3, which are the centers of the gables, lines may be drawn toward S locating on the picture plane the points h', h', and vertical lines under these points projected into Fig. 1, of the drawing plate, will locate the centers of the two wings of the building. Where these lines intersect the gable lines vanishing in Va will be the point of the gable, as shown in Fig. 1 at k. Lines drawn from k to the farther side of the eave lines will indicate the more distant pitch of the gable. Lines drawn from k, also toward VR, will indicate the ridge lines of the roofs over the two wings, and where the line from k to VR on the nearer wing intersects the line from h toward Va, will be the point of the more distant gable at the rear of the left-hand end.

24. Lines from VL through Vb, and from Vr through Va will indicate the traces of the planes TLB and TRA, as explained in *Elements of Perspective*, and the intersection of these traces at V^{45} will be the vanishing point of lines extended at an angle of 45° with the corners of the house (as shown dotted at ax in Fig. 3), but extending upwards at an angle of 45° with the ground. In other words, V^{45} will be the vanishing point of the hips or valleys of intersecting roof pitches at this angle.

Now, the roof of the farther wing of the building, and the

intermediate connecting wing intersect at their eaves in the corner, indicated in Fig. 3 at g'; therefore, the point g' projected into Fig. 1, of the drawing plate, will locate the point e at the lower intersection of these slopes, and a line from e to V'' will be the line of the valley or intersection between these slopes. The line from the farther gable point toward VR will, where it intersects the line from e toward V'', mark the intersection of the ridges of the farther wing and the intermediate section as shown at l, and a line from VL through l, until it intersects with the first details of the nearer wing, will mark the ridge of the intermediate section.

25. The points j', k', l' in Fig. 3, that mark the projection of the chimney to the picture plane, are projected into Fig. 1, of the drawing plate, until they intersect with the farther slope of the nearer roof. The chimney being the same height as the ridge of the roof, as shown in Fig. 2, a line from this ridge k toward VL will mark the height of the chimney at the front of the house, and a line from the point where this line from k to VL intersects with the line through the corner of the house f' toward VR will mark the height of the corner of the chimney on the line projected from k' in Fig. 3. This completes, in general outline, our elevation, with the exception of the openings and the blocks at the corners.

26. These blocks are measured on the measuring line $a\,a$, their dimensions being taken from Fig. 2 and set off from b' to c' in Fig. 1, of the drawing plate. Lines from b' and c' toward VL will mark the heights of these details on the farther side of the wing, and lines from b' and c' toward VR will mark the height of these details at the rear of the wing. Their projection beyond the wing, and also the amount of face that shows, must be determined by drawing lines from these details in the plan in Fig. 3 toward the station point S, thereby locating their intersections with the picture plane. It will be observed that this bracket on the corner a comes below the picture plane; therefore, the

projection of the nearest corner will be thrown back against the plane, as shown by the line from S to n'. In the same manner, the brackets on the farther gable may be located, their measurements being laid off on the measuring line $a\ b$ first and carried to their respective points by vanishing lines toward $V L$.

27. The widths of the openings in the perspective are projected from the plan above in precisely the same manner as were the other features. The heights of the different parts of the openings may be laid off on the measuring line $a\ a$ according to measurements taken from Fig. 2, and projected toward $V L$ and $V R$ to determine these heights in the different wings and different parts of the wings. A partial exception to this is made in connection with the door opening, that being in a recessed portion of the building and therefore not in the same plane as the fronts of the wings.

The height of the door opening is laid off, therefore, from a' to o and a line drawn from o toward $V L$ until it intersects with the corner of the farther wing under d. From this point of intersection a line is then drawn toward $V R$ until it intersects with the inner angle of the farther wing under e, this point of intersection being marked p. From $V L$ a line through p will mark the height of the door.

28. It is necessary, in locating points on a building, to follow the line around all corners and breaks on the building in order that it may come to its proper position in any particular place. This will be explained much more fully as we proceed. The student having finished this drawing according to the above instructions may carefully ink in all the details of the building, as shown in Fig. 1, of the drawing plate.

The points $V L$ and $V R$ may be inked by round black dots, about $\frac{1}{16}$ inch in diameter, as shown, and lettered as on the drawing plate The points $M R$, V, and $M L$ may be inked by similar dots, but not lettered. The traces $T L N$ and $T R N$ and the vanishing points $V a$ and $V b$ may be

inked as on the drawing plate, as are also the planes *T L B* and *T R A* and the vanishing point V''. All the rest of the construction lines may be erased, and the piece of drawing paper at the top of the plate containing a plan of the picture plane, the station point, and the building, may be now removed and the student may proceed to draw Fig. 2, of the drawing plate.

29. Fig. 2 is a perspective view of the window openings on the right-hand end of the former building, but on a scale of ½ inch to the foot, in order to show the detail. The student will first pin over the lower half of his drawing plate a piece of paper, thus covering Fig. 1, and on this small sheet of paper he will draw a horizontal line about 6 inches above the bottom, from the center of which he will lay off, in each direction, a distance of 6 inches, marking *v l* and *v r*, as shown in Fig. 4. The points *m l* and *m r*, and *v* and *S* are located in precisely the same manner as in the previous case. The plan of the window opening is then drawn in place at an angle of 45° with the picture plane, the corner of the nearest opening coinciding with the point *m r*. The plan of the entire opening, consisting of four separate windows and their separate mullions, will then be drawn according to the dimensions shown in Fig. 4, of the text, and Fig. 3, of the drawing plate. The student will then draw a horizontal line on the upper part of his drawing plate, 6¼ inches below the upper border line. He will then draw through *v l* and *v r* of his plan vertical lines intersecting the horizontal line just drawn, and thereby marking the points *V L* and *V R* of his horizon. The measuring points and central vanishing point may then be projected as before.

30. An elevation of one of the window openings may be drawn in the upper right-hand corner of the plate, as shown, according to the dimensions given in Fig. 3, of the drawing plate. Then proceed to draw the perspective shown in Fig. 2, of the drawing plate. The window opening, Fig. 3, of the drawing plate, is located so that the horizon line passes

2 feet above the top of the sill, and the line of measures *a a* in Fig. 2 corresponds with the corner of the stonework on the nearest opening.

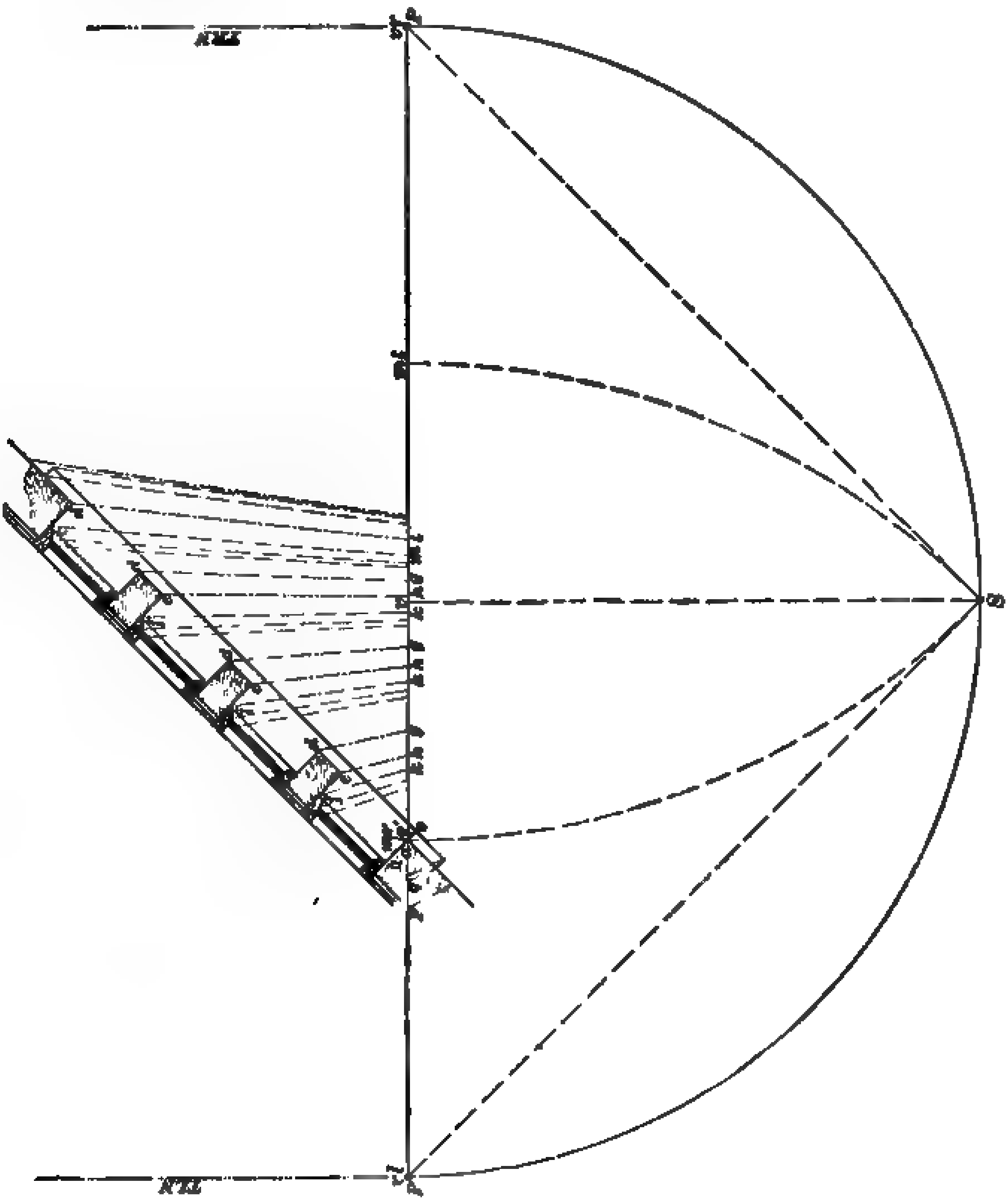


FIG. 4

31. Draw *a a* directly over the point *a* in the plan below, and lay off, along this line, the heights of the main opening,

the thickness of the transom bars, and the heights of the openings above as projected across horizontally from the elevation of the window opening in Fig. 3, of the drawing plate. Draw indefinite lines from the points so marked through the line *a a* toward *V R*. Draw in the plan pinned below lines from the farther corners of the opening toward the station point, as shown at *b S* and *c S* in Fig. 4, of the text; then in succession draw toward *S* lines from *d*, *e*, and *f* marking the perspective dimensions of each of the mullions on the picture plane. Project these points *g*, *h*, and *k* for each mullion, and *l* and *m* for the farther corner of the window, across the horizon line in Fig. 2, of the drawing plate, and outline the exterior openings of the windows as shown at *b*, *c*, *d*, *e* in Fig. 2, of the drawing plate. From *b* draw a line toward *V L*, and where this line intersects with the line projected vertically from *h* in the plan below, draw a line marking the depth of the top of the window, this line converging toward *V R* and shown in Fig. 2, of the drawing plate at *f g*.

32. The other lines of the openings are similarly located by projecting their perspective widths to the picture plane in plan, as shown in Fig. 4, transferring these perspective widths along the horizon line in Fig. 2, of the drawing plate, through which vertical lines are drawn marking their positions, and the perspectives of horizontal lines drawn from adjacent parts to limit their dimensions.

33. In order to locate the height of the lower rail of the sash in Fig. 2, it is necessary to locate the line *m l* which shows the location on the picture plane of the inner corner of the window. This line, though hidden by the projection of the mason work in Fig. 2, of the drawing plate, is shown dotted in its proper place at *l* in order that the point *m*, where it intersects with the wooden sill, may be located. The height of the sash above the wooden sill is then projected across from Fig. 3 to *o* in Fig. 2 on the measuring

line, and from *o* projected into the line *m l* at *S*. A line from *S* toward *VR* will mark the top of the lower sash rail in each of the four openings, and a line from *m* toward *VR* will mark the bottom of the lower sash rail in all four openings.

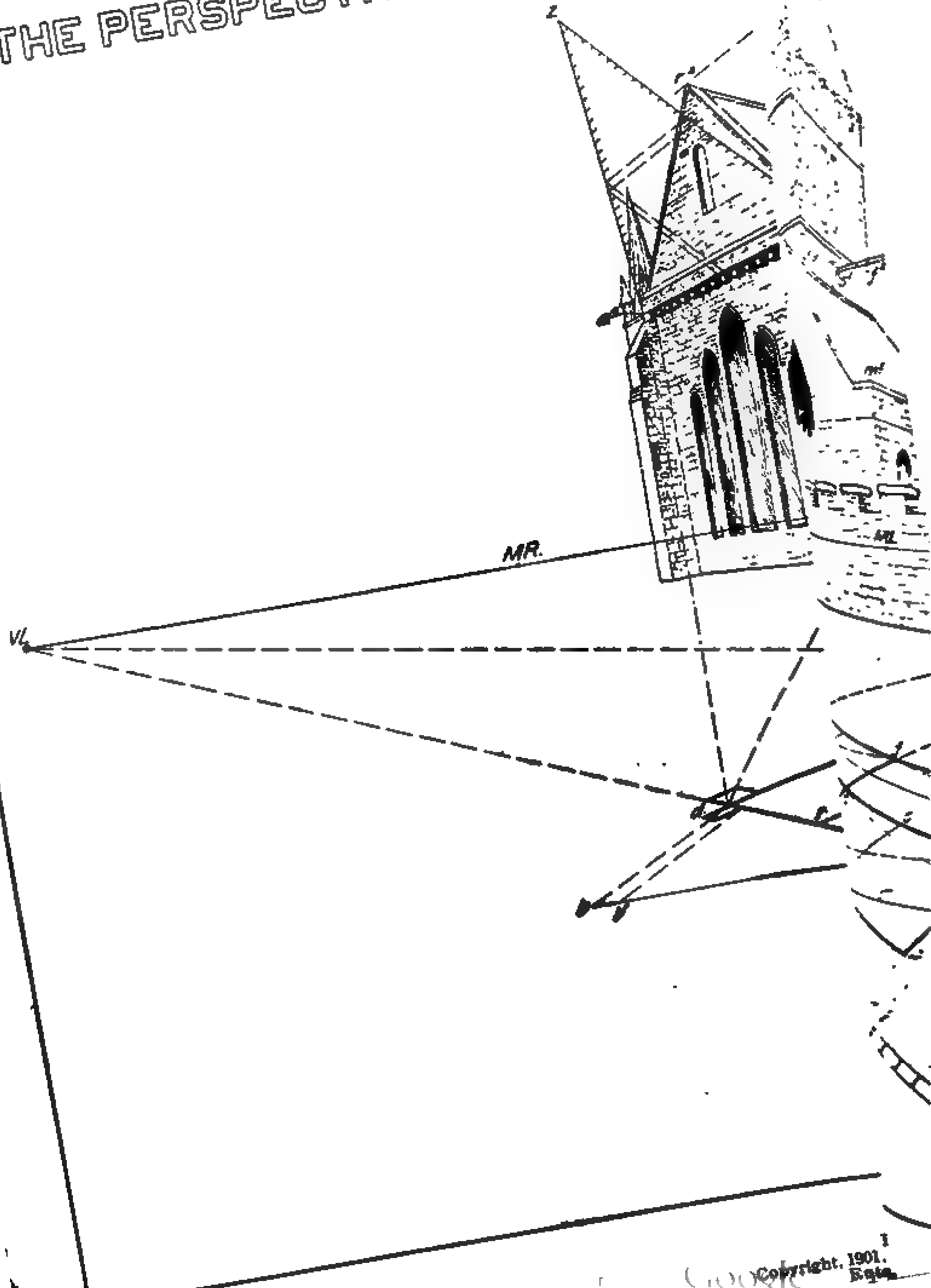
34. It will be observed in the plan, that the window sill projects 3 inches beyond the main wall line, and to indicate this projection properly it is necessary to extend the side of the jamb from *a* to *o*, as shown in Fig. 4. The point *o*, located on the picture plane at *o'* by means of a line from *S* through *o*, may now be projected into the perspective in Fig. 2, of the drawing plate, by means of a vertical line over *o'*, as shown at *t t*.

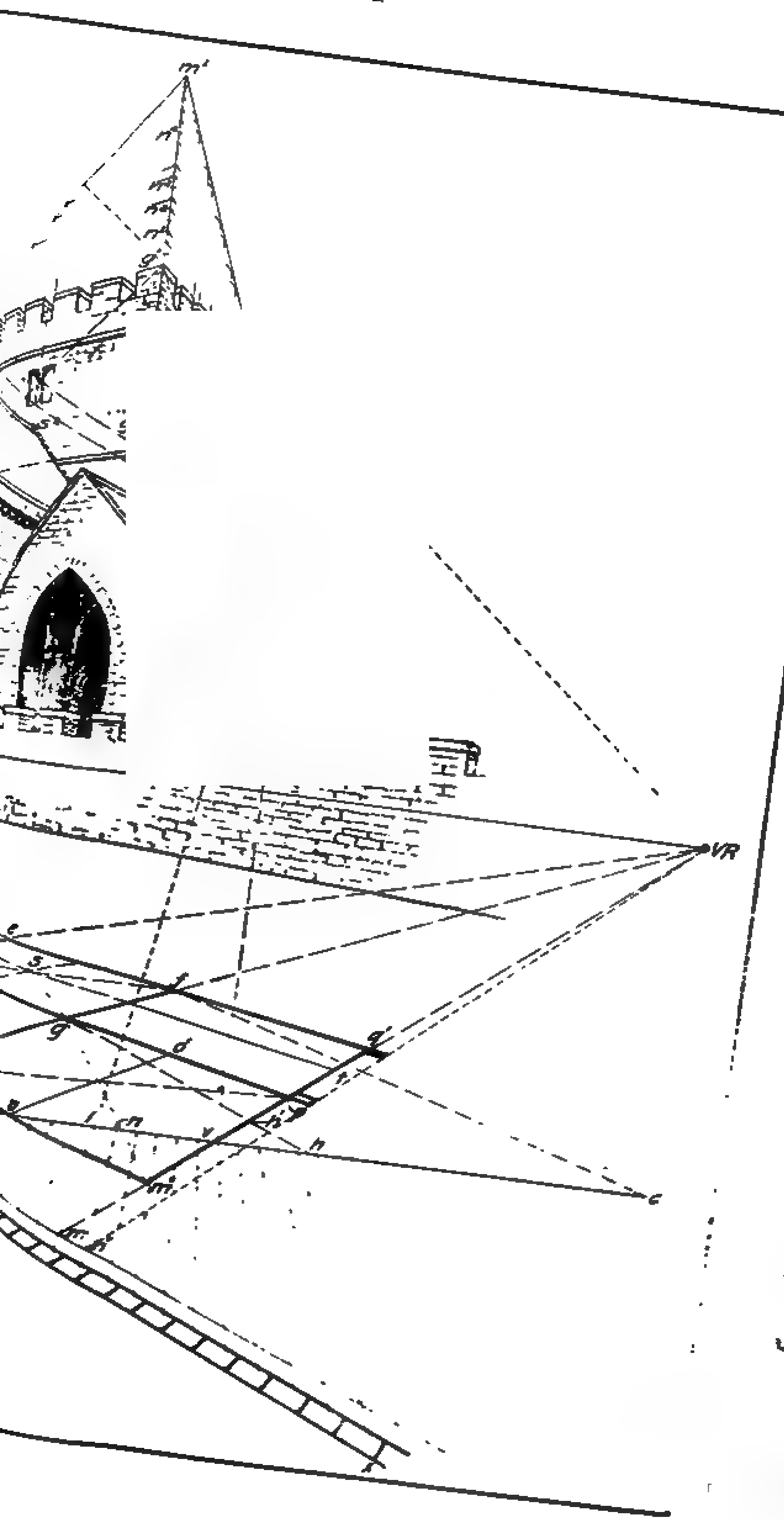
A line from *VL* through the lower corner of the jamb of the window will indicate the height of the top of the sill. Six inches below this, on the line *a a*, another point should be located, through which a line from *VL* is drawn intersecting *t t*, thus marking the lower side of the sill. The sill itself, however, on its outer edge is only 4 inches thick; therefore, 4 inches should be laid off above the bottom of the sill on the measuring line, and the point so found transferred to the line *t t*, the outer edge of the sill, by means of a line from *VL*, thus marking the outside thickness of the stone sill.

35. The quoin stones shown at each side of the window are 8 inches in thickness and are transferred directly to the measuring line from the elevation in Fig. 3. Their lengths, however, must be laid off in the plan according to their linear dimensions, as shown in Fig. 4, of the text, and these linear dimensions must be converted into perspective dimensions by projections to the picture plane, as shown at *p* and *q*. Their position in the perspective above can then be directly transferred.

Having completed all these details, the student will erase all his construction lines and leave Figs. 2 and 3 inked in, as shown on the drawing plate. Omit all reference letters and

THE PERSPECTIVE PLAN.





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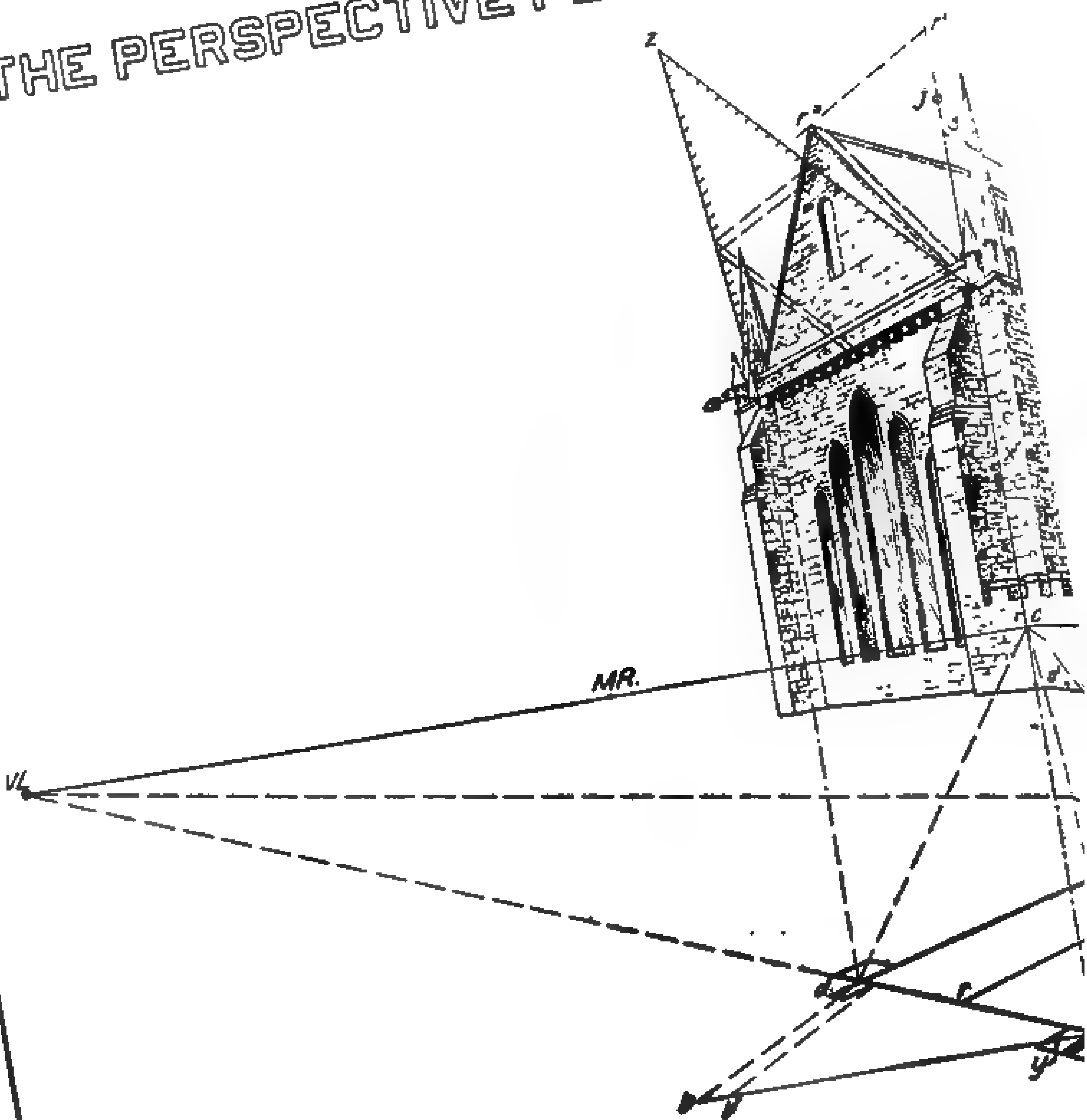

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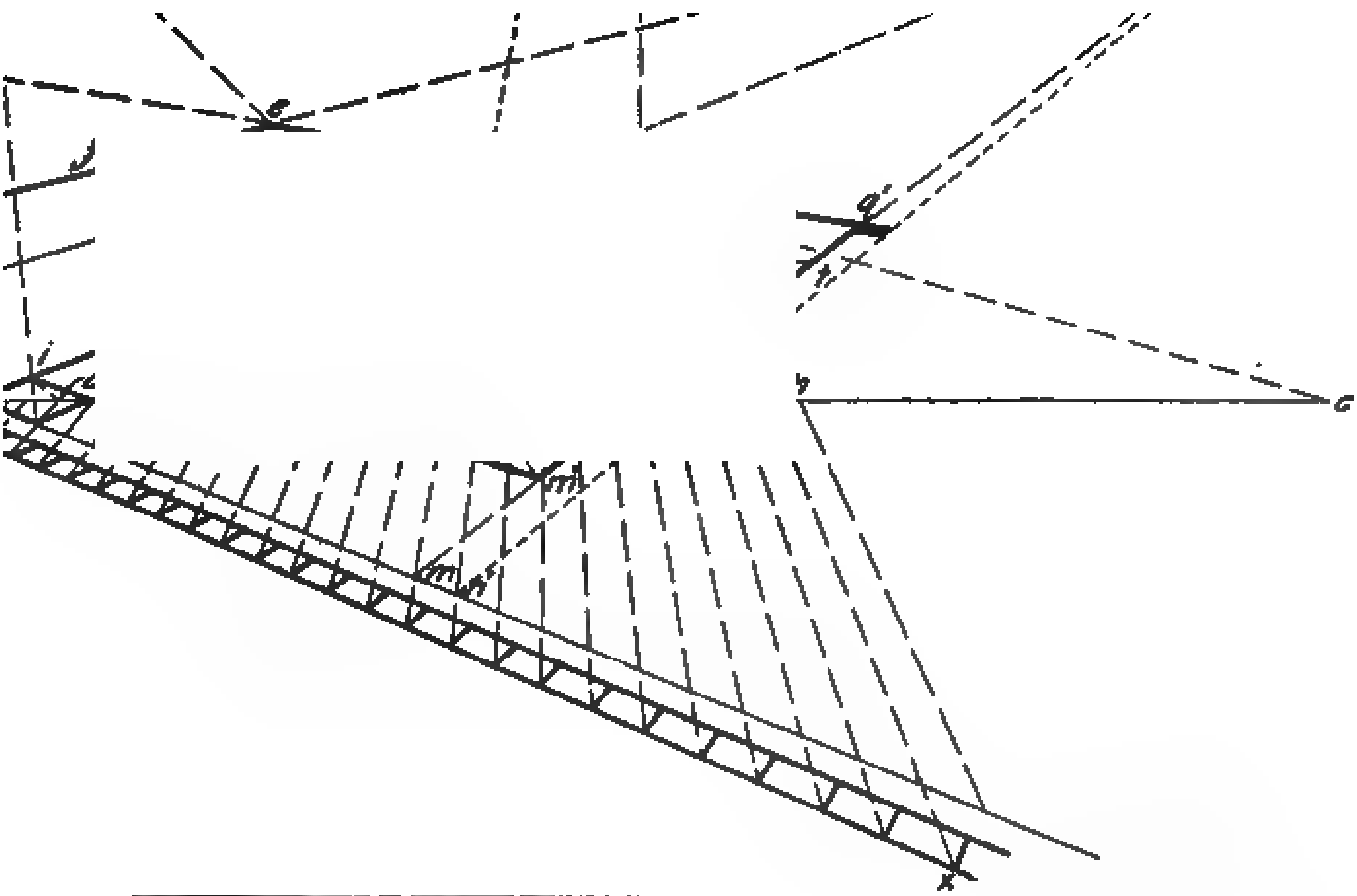


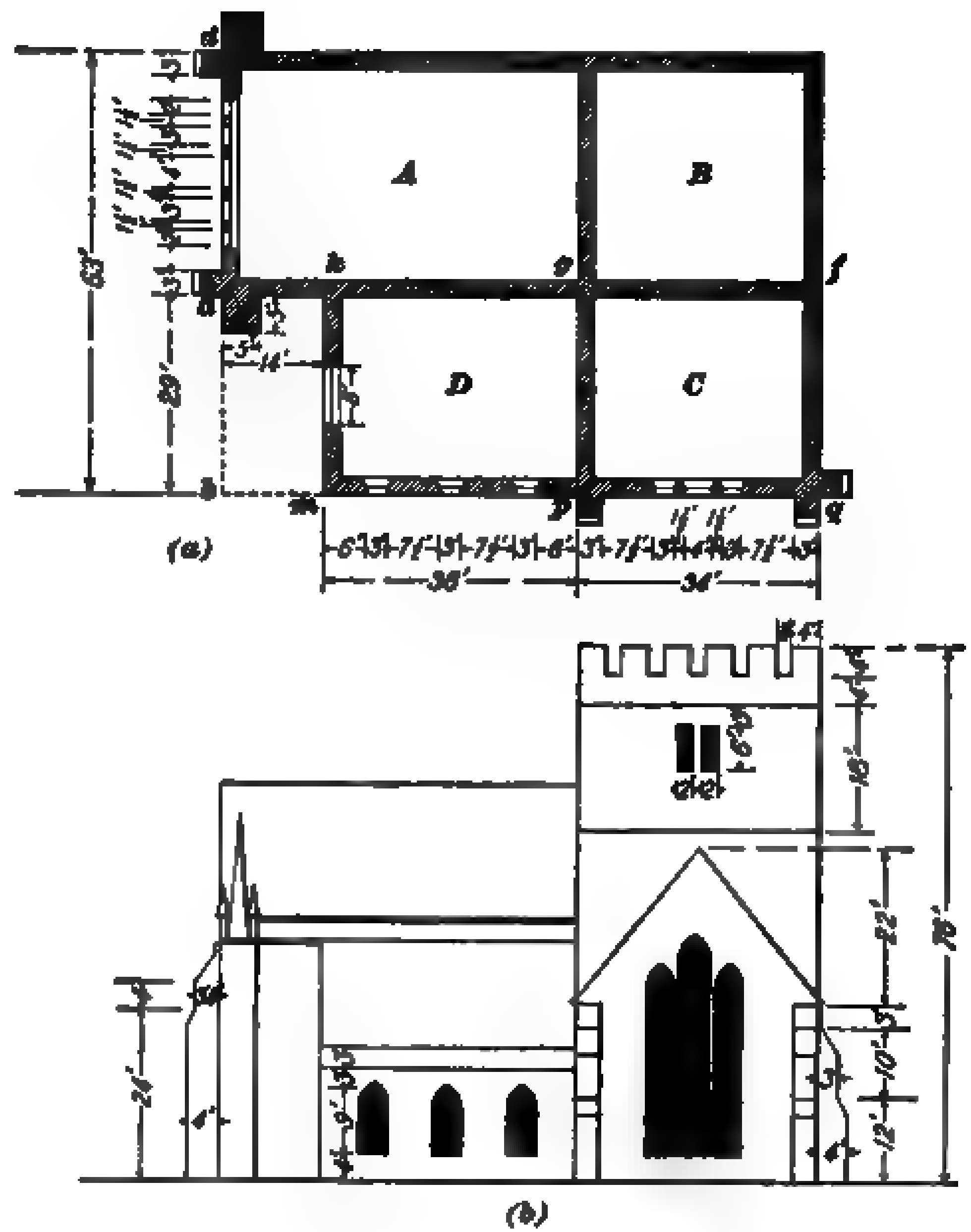
all dimensions except the vanishing points VL and VR, which will be inked as before. The title may then be drawn at the top of the plate, the name, class letter and number, and date being printed as heretofore.

DRAWING PLATE, TITLE: THE PERSPECTIVE PLAN.

36. On this plate the student will execute the figures without recourse to the complicated and room-taking arrangements that were practiced on the previous plates. He will here work out his perspective plan according to the explanations given in *Elements of Perspective*, and will lay out a building with as few preliminary preparations as is possible. The plan and elevations of the building are shown in Fig. 5 where all the dimensions are marked, so that it will be necessary for the student simply to follow these dimensions in his drawing plate and not redraw the plans and elevations as here shown.

The scale is $\frac{3}{32}$ inch to the foot, and the student will commence by drawing his plane of measures $b\,c$ $2\frac{7}{8}$ inches above the lower border line, and his horizon line VL–VR $6\frac{3}{16}$ inches above the lower border line. The distance between the points VL and VR is 16 inches, and after locating them the student will mark the center of vision C midway between them. MR and ML will then be located in their proper places, as heretofore explained, either accurately as on the previous plate or according to the approximate method explained in *Elements of Perspective*.

37. At a on the measuring line $b\,c$ directly in front of C locate the corner of the plan of the building marked a in the plan, (a), Fig. 5, and make the sides $a\,d$ and $a\,f$ recede from the picture plane at an angle of 45° as well as with the line from a into c the center of the picture. In other words, lines from a to VL and VR will mark the directions of the sides of the building in plan. The length of the side $a\,f$ will be determined by laying off from a toward c a distance



(c)

Fig. 5.

of 84 feet, and from c drawing a line toward MR until it intersects the line from a to VR at f. A line from VL through f will then mark the direction of the upper end of the building.

38. In the same manner, the width of the building from a is laid off 34 feet to b and a line drawn from b toward ML. Where this line intersects the line from a to VL at d, the width is marked, and the line from d toward VR completes the rectangle representing the main structure of the church and the tower, as indicated by the letters A and B in Fig. 5 (a). It is evident, however, that the tower at the upper end of the church is square. Therefore, a line from C through e will mark at g the width of this tower fg equal to its other width ef, because C is the vanishing point of 45° and the line geC is at an angle of 45° with ef and ej. The line gj may now be drawn from g toward VL marking the square of the tower in plan.

39. The width of the wing on the side of the church, shown at D, in Fig. 5 (a), will now be laid off from a 29 feet to l, and the line from VL through a must be prolonged below the measuring line bc indefinitely, as shown. From ML through l, a line is then drawn intersecting the line VL-a prolonged at m, and from m, a line toward VR will mark the side of the wing and the front of the extension to the tower, shown at mp and pq in Fig. 5 (a).

40. The reason that the point m is taken below the measuring line bc is, because the corner of the wing will come below bc according to this arrangement, and we locate at m the point where the side of the wing would intersect the front wall of the main building if the front wall and wing were prolonged, as shown by the dotted lines ab and mb in Fig. 5 (a), the point m on the drawing plate representing the point b in Fig. 5 (a).

41. However, the main wall of the building a sets back a distance of 14 feet from the corner a, as shown in Fig. 5 (a);

therefore, on the drawing plate it is necessary to lay off from a to k a distance $a\,k$ equal to 14 feet, and draw from k toward $M\,R$ a line intersecting the wall of the main building at k'. $k'\,m'$ drawn through k' from $V\,L$ will then be the line of the back of the wing, as shown in Fig. 5 (a) at $k\,m$.

42. The addition to the tower, shown at C in Fig. 5 (a), is the same width as the tower itself and may be drawn in the plan of the drawing plate by extending the sides of the tower $e\,f$ and $j\,g$ until they intersect with the side $m'\,q'$ drawn toward $V\,R$. This completes, in general outline, the plan, but if the line $j\,f$ of the tower is drawn through the diagonally opposite corners we have at s, where this line crosses $e\,g$, the center of the tower, as explained in *Elements of Perspective*, and a line from $V\,R$ through s to r will mark the ridge of the roof over the main section of the church. In the same manner, a line from $V\,L$ through s to t will mark the ridge over the addition to the tower. The ridge over the wing D, Fig. 5 (a), may be drawn by means of a line from $V\,R$ through the intersection of the diagonals $m'\,g$ and $k'\,p$ as shown at $o\,o'$ on the drawing plate.

43. As a usual thing in locating any point on either side of the plan of a building when drawn in perspective in this manner, the distance of that point from the point of a building in contact with the measuring line, as a, is laid off to the right or left of the point of contact according to which side of the building it is on—to the right when the right side, to the left when the left side. From the point so located on the measuring line, lines are drawn toward the right measuring point $M\,R$ when the point is on the right side of the building, and the left measuring point $M\,L$ when the point is on the left side of the building; and the intersection of these lines with the perspective sides of the building will locate the required points.

44. To illustrate this, lay off from a toward c a distance of 50 feet to h, which is the length of the main body of the church A in Fig. 5 (a); it is desired to locate the point g on

the right side of the building where the main portion ends and the tower begins. Therefore, from *h* draw toward *M R* a line intersecting the side of the building at *g*, this being the same point exactly that was obtained by the diagonal or 45° line through the square plan of the tower at *e g*.

However, there is a slight exception to these rules when the portion of the side of the building on which the point is to be located extends below or in front of the measuring line, and this was the case in the location of the point *m*. The side *d a* of the building is undoubtedly the left side and it still remains the left side when it is extended indefinitely toward *m*. Therefore, when the distance *a l* is laid off to the right of *a*, in order to measure that distance from *a* on the side of the building draw the line from *M L* through *l* to *m*, because *m* is still to be located on the *left* side of the building and being below the measuring line *b c* the distance *a l* is measured to the *right* of *a*. All distances to be measured on the left side of the building above the measuring line *a c* will be measured to the *left* of *a*, as the distance *a b* is laid off to measure the width of the main building as shown at *a d* in the plan.

45. On the corners of the building are two buttresses that are located in the perspective plan by laying off from *a* to the right the distance *a a'* equal to 5 feet, the width of the large buttresses, as shown in Fig. 5 (*a*). The point where a line from *a'* toward *M R* intersects the main building, as at *i*, marks the width of the buttress on the building, and a line from *i* drawn toward *V L* will show the width of this buttress on the other side of the building, also. The lines from *C* through *i*, and *C* to *d*, on the opposite corner of the building will, where they intersect with the line from *i* to *V L* and the line from *a* to *V L*, mark the projection of these buttresses beyond the building, because the buttress is square in plan and the line from *C* is at an angle of 45°.

The buttresses on the end of the building, however, are not square, their projection being somewhat greater than their width. Therefore, lay off from *a* to the left a

distance $a\,y$ equal to 3 feet, the thickness of the buttress, and a line from y toward $M\,L$ will intersect on the line $a\,d$ at a point representing the thickness of these buttresses. In the same manner, lay off from the right of b on the measuring line a distance of 3 feet, and a line drawn from b' toward $M\,L$ will mark the width of the farther buttress on the side $a\,d$ of the building. The projection of the buttress beyond the building line can best be determined by measuring off to the left of a a distance of 4 feet and drawing a line from $M\,R$ through the point so located. The point where this line intersects the line $f\,a\,o$ of the house prolonged, will mark the projection of the buttress, and the projection of the more distant one can be obtained from it.

46. In the same manner, the projection of the buttresses, shown at p and q in Fig. 5 (a), beyond the wing of the tower may be obtained by measuring to the right of l the distance $l\,n$ of 2 feet and drawing a line from $M\,L$ through n until it intersects with the side $d\,a$ of the house prolonged at n'. A line from n' to the vanishing point $V\,R$ will then mark the projections of the piers or buttresses beyond the main line $p\,q$.

47. Extending from one of the buttresses on the corner a is a long stone wall with a battlemented top. The outside of this wall is a continuation of the outside of the buttress, while the inside of the wall is in line with the center of the buttress. The battlements or notches in its top are determined by laying off equally on the measuring line, as shown, distances of 2 feet equal to the width of the battlements and the spaces between them and drawing through these points to $M\,L$ lines to intersect with the long wall $y\,x$. Through the points of intersection lines may be drawn from $V\,R$ marking the position of these battlements in the perspective plan, as shown.

48. Having completed the greater part of the perspective plan, proceed to draw the perspective elevation, first laying out, in a general way, the main lines carrying from a

a vertical line through the whole drawing that will act as a measuring line, and laying off on a, at a distance of 29 feet above and 5 feet below C, lines that mark the main height of the church roof under the parapet, shown in the perspective elevation in the point a^2, and the ground line of the building 5 feet below the center of vision as at a^1. From a^1 and a^2 lines should be drawn toward VL and VR.

49. The lines of the tower should now be drawn and the height of the tower, 76 feet, marked off from a^1 on the measuring line to a^3, as shown. The line from a^3 toward VR will then mark the height of the tower at its nearest corner and the direction of its right-hand side, while the line from the intersection of a^3 toward VR with the nearest corner of the tower at g^1 drawn toward VL, will give the direction of the left-hand side of the tower. The point of the gable of the main roof should now be drawn directly over r of the plan and the height of the gable located on the measuring line $a\,a^3$ at r^1. The line from r^1 toward VL will then mark the point of the roof at r^2, and lines from r^2 to a^3 and a^4 will give the pitch of the gable over the end of the church.

It will be observed that there is a band or corbel course around the tower just below the point of the gable of the main roof and that this corbel course is 26 feet below the top of the tower. If a point is located 26 feet below a^3 or just below r^1 at f^1 and a line drawn from there toward VR, we can establish the line of this corbel course on the tower, and with its intersection with the line under point g^1 of the elevation we can draw toward VL the direction of this corbel course on the left side of the tower. By means of this course we can get two important measurements, because it divides the upper part of the tower into two rectangles, one on each side.

50. By drawing the diagonals of these rectangles, as shown at $g^1 f^1$ and $g^2 f^2$, we can locate the center line of each side of the tower and thereby the points of intersection

that the ridges of the roofs make with the tower itself. A line drawn from r^2 toward VR will denote the length of the roof, as at $r^2 s^2$, and a line from s^2 toward the intersection of the line from a^2 to VR and the corner of the tower will mark the farther pitch of the roof.

51. In the same manner, the ridge point at t^1 and the ridge from t^1 to s^1 may be located and drawn, all the details being measured on the vertical line $a\,a^1$. The height of the point t^1 should be laid off on the line $a\,a^1$, as shown on that line at s, and a line should be drawn toward VR, locating s^1 in the center of the tower. A line from VL through s^1 will give the direction of the gable $s^1\,t^1$ and will locate, at t^1, the peak of the gable where it intersects with the center line over t in the plan below.

The center lines of the tower drawn through s^1 and s^2 could have been obtained without using the diagonals $g^1 f^1$ and $g^2 f^2$ by projecting from the plan the intersections of the ridges from r and t where they strike the tower in the plan, either way bringing about exactly the same results. We have now, in general outline, all the details of the main building, the tower, and the tower addition.

52. Now project upwards lines from $k'\,m'$ and q', thus establishing the three visible corners of the wing next the main building, and lay off on the measuring line $a\,a^1$ a distance $a^1\,x^1$ equal to the height of the wing, 19 feet, as shown in Fig. 5 (c), a line from x^1 to VR where it intersects with the line over k' will mark the height of this wing at the eaves next the main building, as shown at k^1, and a line from VL through k^1 will mark the height of the nearer corner at m^1.

53. As shown in the elevation, Fig. 5 (c), the line of the roof intersects with the sides of the building 16 feet above the ground. Therefore, there must be measured off above a^1 in the elevation a distance of 16 feet showing the height of the intersection of the roof pitch with the side of the building. Carry this 16 feet to the vertical line through k^1

and from this point of intersection draw a line from VL intersecting with the line m^1, as shown, thus locating the intersection of the roof pitch on the other corner of the house. The point of the gable of the roof over this section may be located by measuring off above a^1 a distance of 34 feet and drawing toward VR from the point so located a line that will intersect with the vertical line over k' of the plan. A line from VL through this point of intersection will locate the point of the gable over o in the plan. The other point of the gable will be found directly over o' of the plan, and its direction determined in the same manner that the direction of the gable on the nearer end was determined.

54. The height of the parapet wall should now be laid out at 9 feet above a^1 and a line drawn from VL, indefinitely, which will represent the top of the parapet wall. Another line from VL, drawn 7 feet above a^1, will locate the bottom of the indentations or battlements of the parapet wall, and the sides of the battlements may be located by drawing perpendicular lines from their positions in the plan below, as shown.

55. The location of the battlements on the edge of the tower can best be established by the method of triangles explained in *Elements of Perspective.* These battlements are each 4 feet wide and are spaced 2 feet apart. If the upper edge of the tower is divided into 17 equal parts, two of these parts will be allowed for each battlement and one part for each space between the battlements.

56. To subdivide the line $g' f^2$ into 17 equal parts, draw from g' in any direction an indefinite line, as $g' m'$, and lay off on this line to any convenient scale the 17 subdivisions, as at n^1, n^2, n^3, etc. From the last of these subdivisions, as at m', draw a line to f^2, and from each of the subdivisions draw lines toward VR until they intersect with $m' f^2$. From these points of intersection draw lines parallel to $m' g'$ until they intersect with $g' f^2$ and mark by this intersection the subdivisions of the battlements.

Below a^3 we must now lay off a distance of 4 feet, being the depth of the indentations, and from the point so located draw lines toward VR that will locate the bottoms of these indentations in perspective. In the same manner, the battlements may be indicated on the left side of the tower, and the corbel or projection course immediately below them drawn from a point measured off 8 feet below a^3.

57. The corbels under the parapet wall at the end of the building, from a^3 to a^4, are located in the same manner as were the battlements. Any line, as $a^3 z$, can be drawn indefinitely in any direction from a^3, and on it space off evenly 31 divisions representing the 14 corbels and the spaces between them as well as the thickness of the nearer buttress. A line from z is then drawn to a^4, and from each of the subdivisions on $a^3 z$ lines are drawn toward VL intersecting with $z a^4$. Lines from these points of intersection, parallel with $z a^4$, will locate on the line $a^3 a^4$ the subdivisions for the corbels.

58. The location of the windows may then be found by projecting them from the plan after they have been located according to methods already explained, remembering that all measurements for walls on the right of a in the plan and above the measuring plane must be measured on the line bc toward the right from a and projected to the measuring point MR; and that all points on the left-hand side of the building must be measured to the left of a when they are above the measuring line and projected toward measuring point ML.

59. The intersection of any lines from measured points on bc toward the measuring points MR or ML are of value only where they occur on the line ad or af. For instance, the measurement taken from a toward h is of no value where it intersects the side of the building at h', but it is of value where it intersects the side of the building at g because the side of the building containing the point g passes through the point a. All measurements so taken must be carried

from the main lines of the building to the other lines, as was done when the point m' was being located. The width of this wing on the front of the building was first located as it would occur at $a\,m$ and was then projected back in the direction from m to VR until it intersected at m' with a line through k', which was found by measuring the distance back from a to k.

60. The location of the buttresses and other details that have not been explained separately, should now be easily carried out by reference to the drawing plate, the essential points being to take all vertical measurements on the line $a^1 a^2$ and to carry these vertical measurements down the sides of the main building around each side of the buttress until they come to the desired location. This carrying around can easily be determined by reference to the plan.

61. To locate any given height on some portion of the front of the addition to the main tower, as shown at $q\,q'$, it will be necessary to measure this height on the corner a over the plan, carry it toward k' in the plan, thence toward m', and thence down the side from m' to q'. This will represent a level line around the building, and if it were to go from a in the other direction, it might go straight from a to d or it might go around all three sides of the buttress in order to locate some point on the front of the buttress.

62. If the line to be located were above the roof of the wing next the main part of the building, it would have been easier to measure its height on the line $a^1 a^2$ and then to carry it to the corner g of the tower plan, then, from g out to the corner p of the tower wing, and from p across the front to q', as shown in the plan, this being the regular way of traversing and keeping on walls at certain levels.

It will be remembered, as said heretofore, that all lines in a plane of measures may be drawn to the same scale; therefore, it is very evident that where the lines of the wing next the main building cross the plane of measures, as at o and v, we can take actual measurements as to the height of details

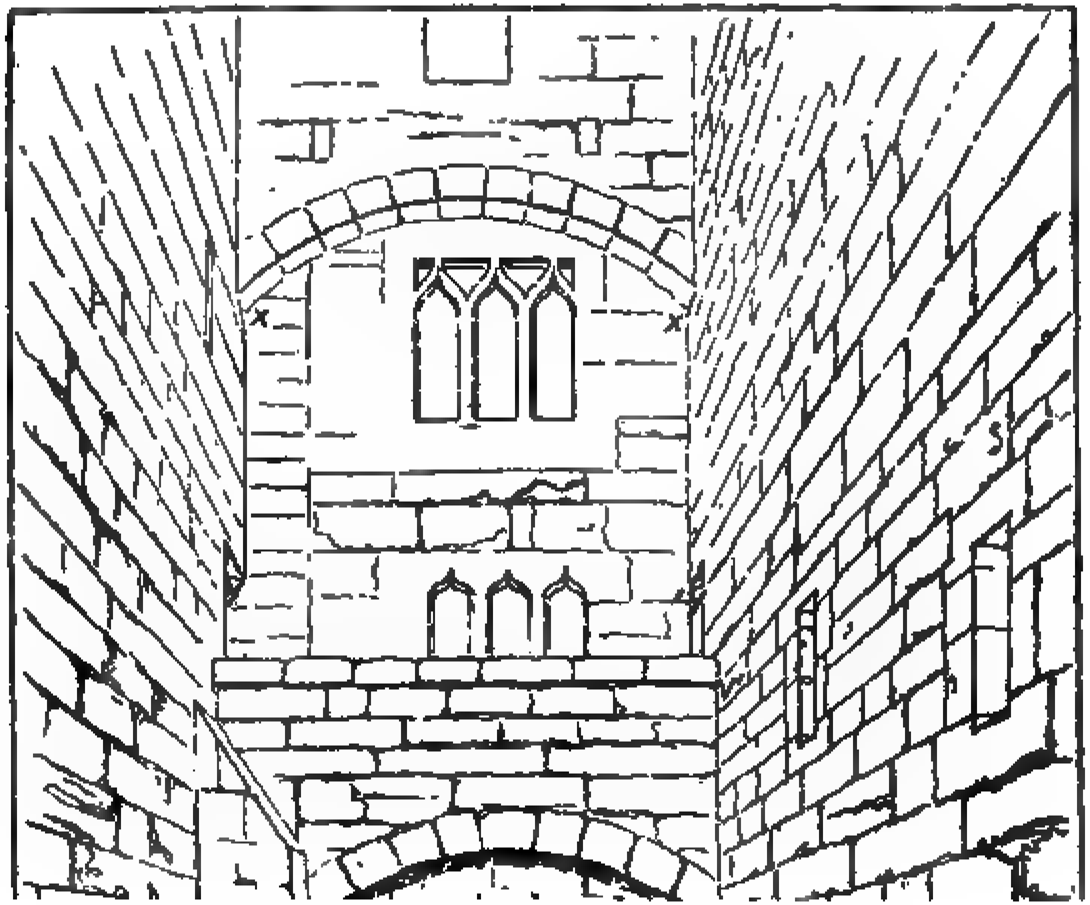
at this point. Therefore, in locating the heights of the windows on the side of the wing next the main part of the church those heights may be laid off on the line $v\ v'$ and projected in each direction to the corner of the building to locate the windows on the side, or around the corners of the building to locate the main window in the center of the end, or a line may be drawn through o to represent the center line of the window, on the end of which the direct height of this window may be laid off according to the figured dimensions in Fig. 5 (*c*).

63. For the sake of practice, it will be well for the student to divide this problem into several smaller ones before he attempts his drawing plate. Take the tower and the main building without either of the additions or extensions and consider it as one problem. Then make another

FIG. 6.

drawing of the tower and main building, with the extension to the tower, omitting the addition entirely. Finally draw the three of these together as on the drawing plate. In this way, the student will become familiar with the details of

PARALLEL PERSPECTIVE.



each part and will find no difficulty in his final execution of them, whereas, if he attempts to do the whole thing at once, the putting of so many rules into practice at one time will appear very complicated to him.

Follow every detail that is given in the text as you proceed with the work. Nothing is left unexplained, and by paying close attention to all the description you will see the development of the perspective figure grow under your handling, and any difficulties that may be encountered will be overcome by giving it a little serious thought and study.

64. After the plate is completed in pencil, ink it in freehand, with the exception of the plan, which may be inked with instruments. After inking, clean the plate thoroughly and indicate the stonework and details, as shown in the original. Place name and date as usual outside the border line. The closeness with which the mechanical perspective follows the photographic rendering can be determined by comparing the perspective sketch with Fig. 6, of the text.

DRAWING PLATE, TITLE: PARALLEL PERSPECTIVE.

65. In this drawing plate is represented a view of the portcullis, or entrance gate, of Warwick Castle, England, a photograph of which is shown in Fig. 7. The ground plan and elevation of this entrance gate is shown in Fig. 8, and the upper portion in Fig. 9. The elevation, Fig. 8, shows only the portion of the structure that is parallel with the picture plane, as there are so few details in the side walls that we can obtain these very readily from the plan and certain given dimensions.

66. Begin this plate by drawing the horizon line $VL-VR$, 8 inches above the lower border line, and locate the vanishing points thereon 13 inches apart. The points ML, MR, and V may then be located as usual. Draw a line of measures, as $a\,b$, at any convenient point about 4 inches above the

lower border line and from its middle point *c* directly under *V* lay off to the right and left 10 feet, to *e* and *d*, or one-half

FIG. 7.

the entire width of the passageway, at a scale of $\frac{1}{8}$ inch to the foot. From *d* to *f* lay off 3 feet 6 inches as the width of the buttress of the left side of the entrance, and from *f* to *g*,

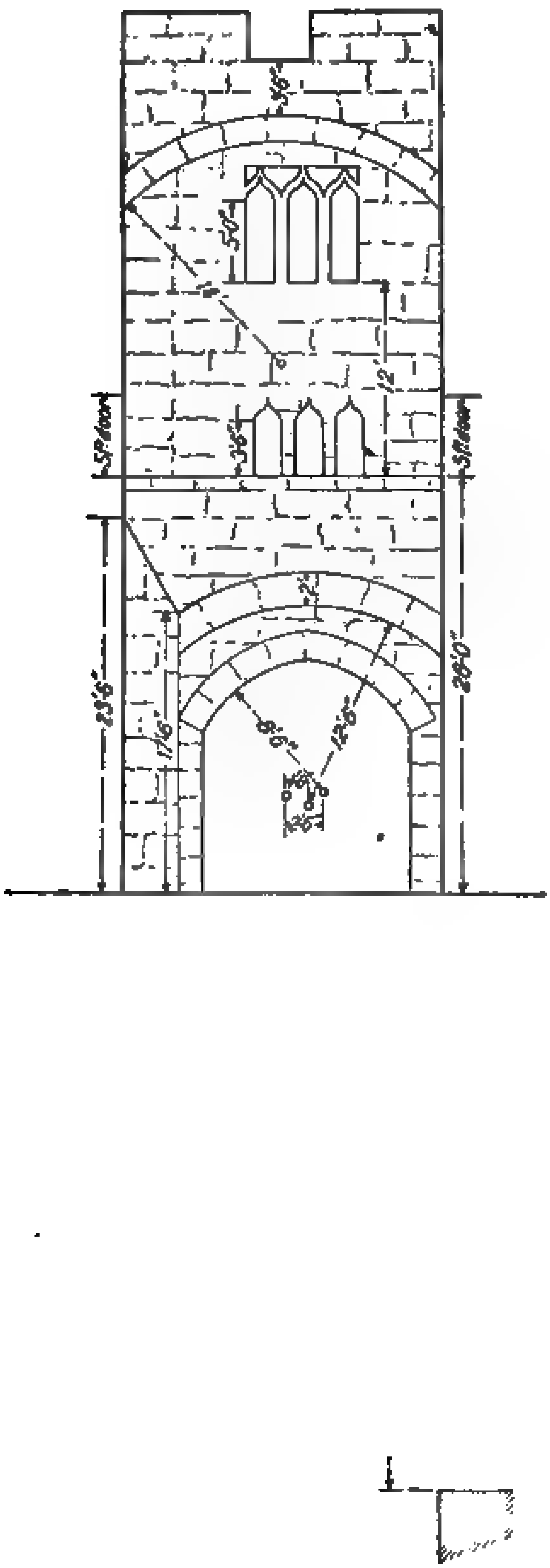


Fig. 8.

1 foot 6 inches, the width of the pier on the side of the opening. The pier on the other side is 2 feet, as shown in the plan Fig. 8, and that distance should be laid off from *e* to *n*. Lines drawn from *d*, *e*, *f*, *g*, and *h* toward *V* will represent parallel lines perpendicular to the picture plane spaced distances apart equal to the measurements that have been laid off.

In Fig. 8, the picture plane is placed at *a b* just inside of the narrowest passage. This point has been taken because it coincides with the face of the entrance and renders the projection of the elevation somewhat more simple. Complete the perspective plan before drawing any of the perspective elevation.

67. The lines *k k'* and *l l'*, representing the general direction of the side walls of the passage, are 10 feet each side of the vertical center line, and all measurements

should be taken on them. From *d*, the point where the line *k k'* crosses the line of measures *a b*, lay off a distance to the right *d m* equal to 4 feet, and *m n* equal to 5 feet, corresponding with the measurements in Fig. 8 that locate the position of the vertical gate *c* and the outside of the wall at *d*. A line drawn from *m* toward *VL* will intersect *k k'* at *m'* and will locate the position of the inside of the gate as shown. A line drawn from *n* toward *VL* will intersect *k k'* at *k* locating the outside line of the wall.

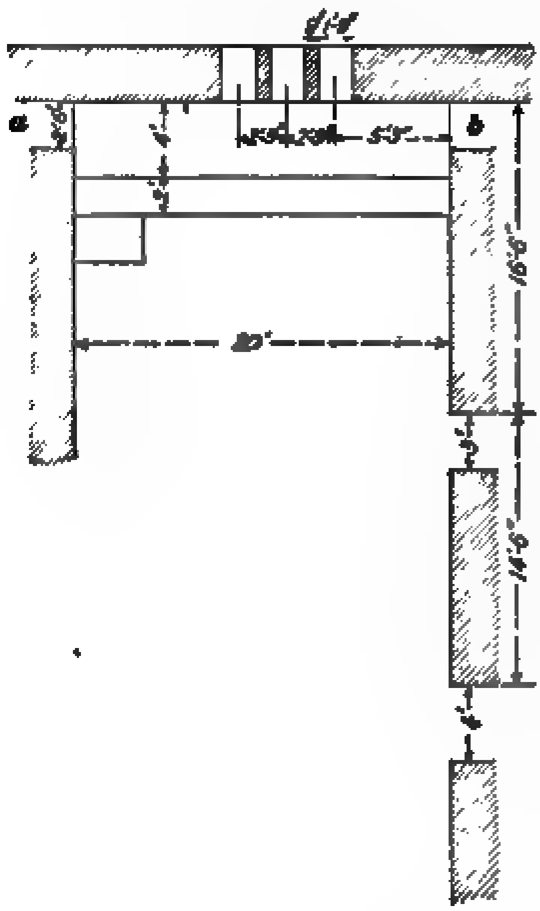


FIG. 9.

68. The reason for this should be apparent. The line *k k'* vanishes at *V*, the center of the picture; the lines *m* to *VL*, and *n* to *VL* vanish 45° to the left; and the line *a b* is parallel to the picture plane and therefore at right angles to all lines vanishing in *V*. Any distance, as *d m*, laid off on *a b* is equal to the distance *d m'* marked on *k k'* by the line *m* to *VL* receding 45° to the left. In the same manner, lay off the distance *d o* to the left of *d* equal to 8 feet 6 inches, and from *VL* draw a line through *o*, marking the point *o'* the end of the buttress. The angle *o d o'* is a perspective view of a right angle, and the angles *d o o'* and *o' o d* are angles of 45°; therefore, the distances *d o* and *d o'* are the same.

69. In the same way lay off to the right of *c* the distance *c p* equal to 9 feet 6 inches, and the distance *p q* equal to 10 feet, the width of the door shown on the plan, Fig. 8. Lines from *VR* through these two points will locate the door opening on the line *l l'* at *p'* and *q'*. This will prac-

tically complete the ground plan in perspective, and lines can be drawn from these to locate the positions of the various details in the perspective elevation.

The line *r s* in the elevation is exactly 13 feet below the horizon, and with it as a ground line draw the elevation of the doorway according to the dimensions given in Fig. 8. The arcs of the curve of the top of this opening are 8 feet 6 inches in radius, as shown in Fig. 8, and the centers are 2 feet 6 inches apart. The radius of the curve of the big arch supporting the gallery wall is 12 feet 6 inches, and its center is 1 foot 6 inches to the right of the center line and 6 feet 6 inches below the horizon. This curved arch, however, projects somewhat and it is necessary to get the location of the lines limiting the amount of this projection. So, from *e* lay off to the right a distance of 6 feet 6 inches and locate the point *t*. Then, from *VR* draw a line through *t* locating *t′*, the right-hand edge of the gallery. This will locate the vertical line *v v′* in the elevation, and a line from *V* through *u* until it intersects with *v v′* will locate the point *v* from which to strike the curve limiting the soffit of our arch from the same center but with a slightly longer radius than the curves previously drawn. The voussoirs, or arch stones, are 2 feet deep, and by increasing this latter radius 2 feet the top curve of these may then be struck.

70. The heights of the two sides of the buttress, 23 feet 6 inches and 17 feet 6 inches, may then be laid out and the buttress drawn in place. The intersection of the arch with the face of this buttress may be located from the plan by projecting the intersection of the wall of the gallery, as shown by the dotted line at *w*, up to the perspective elevation. The line *u v* on one side, and another line exactly opposite on the other side where the upper part of this gallery wall intersects with the main side wall *k k′*, may now be drawn, and the coping of the gallery laid off as shown according to the dimensions in Fig. 8.

71. The door in the side wall of this passage, shown at *p′ q′*, may now be projected upwards and its height to the

point of its curve laid off as 8 feet from s to s' at the intersection of the wall and the door jamb. A line from V through s' will then establish the height of the straight portion of the door, thereby forming a rectangle whose four corners may be connected, as shown on the drawing plate, and the center established, over which the point of the arch may be located. The height of this point is measured off 13 feet above s, and a line from V through the point thus located will intersect the line over the center of the door opening just laid out at the point of this arch.

72. The upper portion of the structural work is practically over this door entrance, and may be laid out directly to scale as was the door. Care must be taken to proportion the windows and show the details of their construction according to the dimensions given in Figs. 8 and 9, and the projecting arch over the upper set of windows is drawn with a radius of 14 feet on the main wall of the building, the center being located exactly in the center of the picture and 20 feet 6 inches above the horizon. Lines from V through the intersection of this arc at $x\,x'$ with the side walls of the passage will give the directions of the vanishing lines of intersection where this arch strikes the side walls. The amount of its projection may be determined by laying off on the measuring line below a distance of 1 foot 6 inches to the left of d and drawing a line from VR marking its intersection with the line $k\,k'$. The intersection of this line with the line from V through x will locate the point from which to strike the second arc of the soffit of the stone arch, with the same center as the first one. The depths of the arch stones, etc. are shown in Fig. 8.

73. In Fig. 9 are shown the locations and dimensions of two windows, which should be plotted in the perspective plan as were the other details, measured in vertical height on the perspective elevation as were the doorways and original windows, and projected to the side walls as shown. The best way of doing this will be to divide the parallel

part of the elevation into stone courses, as shown in Fig. 8, and then to project from the vanishing point V the heights of these various stone courses, and locate the top and bottom of the two irregularly placed windows according as these courses come.

74. Two door openings across the gallery passage are marked on the drawing plate at y, their widths being shown in Fig. 9 as 2 feet 6 inches at a and b. Their height is shown on the elevation, Fig. 8, as 5 feet above the parapet wall. The other details in the upper part of this elevation may be drawn freehand, after which all the dimension lines should be removed from the perspective elevation and the whole inked in with a fine freehand line, as shown.

75. In order to maintain the effect of distance, the lines should be a little stronger and more distinct on the edges of the picture or foreground than they are in the distance, and the student in outlining the stonework may make the subdivisions more pronounced in the foreground than in the distance. The portcullis, or gate, across the entrance may be drawn with T square and triangles, in pencil, but should be inked in freehand. Observe that the vanishing point V occurs at the intersection of the second vertical bar to the left of the center of the gate, and being on the horizon locates the position of the second bar below the top of the gate. The plan may be inked in and cross-hatched as shown, after which the title should be placed at the top of the plate, and the name, date, and class letter and number at the bottom, as usual.

HISTORIC ORNAMENTAL DRAWING.

(PART 1.)

INTRODUCTION.

1. This branch of the instruction will treat entirely of the application of the elements of design to the various styles of ornament that have characterized certain races of people or periods of history. The student by this time should be familiar with the characteristics of each general style of ornament, and also with the fundamental principles that have governed the details of that ornament. We have traced the development of ornamental design from its earliest civilized period down to the present day, and have found in all instances that, during the best periods of art, the same general underlying principles have governed each style.

In adapting natural forms to strictly ornamental work, there has ever been a tendency to represent those forms in a general, or, as we term it, a conventional way; but the earlier influence of a strictly geometrical ornament is always traceable through the natural forms. For instance, in the Egyptian wave ornament, afterwards adopted by the Greeks, we find a development of the old primitive straight-line zigzag, and in the wall decorations of the Renaissance period, wherein the fleur-de-lis and other strictly conventional forms repeat themselves, we find the influence of the

old Greek brush-work honeysuckle design, that might be said to have for its type not a form of nature but a form of instrument. We have seen, too, in medieval art, the influence of the triangle and the pointed arch, not only in structural work, but also in wall decorations; while with the Arabs and Moors, whose religion restricted them in the use of natural forms, we find the highest development of geometrical work wherein forms are adopted from nature, but reduced to such geometrical principles that they would conflict in no way with any religious restrictions.

2. The student will execute these plates in pencil, and lay his water-color wash with the brush, without any intermediate inking in except where specifically so directed. The purpose of the first four plates will be to represent design in tints, each tint expressive of a different shade of color, after which the execution of designs in color itself will be considered, while instructions will be given for the drawing of each individual figure on each plate.

The student is here directed not to undertake the execution of any design on his drawing plate until he has completed it one or more times on a separate sheet of paper. To the student that has practiced diligently on the previous exercises, there is no problem here that will be difficult, except in the matter of accuracy of measurement and precision of drawing. Freehand work enters largely into the designs, but none of it is of such a character that one who has mastered the previous plates cannot readily execute it.

Remember that many of these designs are duplications of ancient examples of ornament that have existed in important periods of art history, and that in rendering them, a student must bear in mind, in each case, the conditions that have characterized these periods, and represent each example exactly as he finds it on his drawing plate. There is no opportunity here for invention; and, though the work is almost strictly of a copying character, its details are such that no one could copy it correctly without due familiarity with the ancient principles that govern it.

HISTORIC M

Fig. 1.
Egyptian

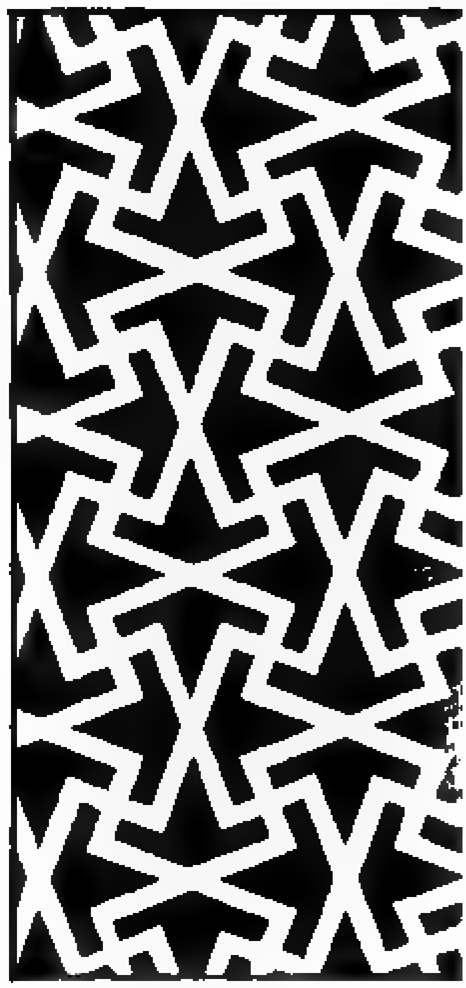


Fig. 4.
Medieval

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: MURAL DETAIL.

Fig. 2.
Greek

Fig. 3.
Roman

Fig. 5.
Mo-esque

Fig. 6.
Persian.

3. Nearly all of these designs will be executed, at least partially, with drawing instruments, and such of the work as is freehand will be governed largely by mechanical measurements that the student must lay out very accurately and carefully. The success of all geometrical repeating ornament depends as much on the draftsman's skill in the use of his instruments as in his familiarity with any type of design, and attention must be given in the division and subtraction of a line to see that it is carried out according to instructions, down to the minutest detail. In many figures, an error of the minutest fraction of an inch will repeat itself to such extreme proportions as to render it almost impossible to make the figures close in and repeat.

DRAWING PLATE, TITLE: HISTORIC MURAL DETAIL.

4. On this plate are given six examples of the style of wall decoration characteristic of the Egyptian, Greek, Roman, Medieval, Moresque, and Persian styles. They are numbered in their order of antiquity as closely as possible, in order that the relative values of each may be compared with its predecessor, and no attempt has been made to graduate the exercises on this plate to put the simpler ones first, as all should be within the ability of the student at this stage of his studies.

After drawing the border line to enclose a space on his drawing plate of 13 in. × 17 in., the student will divide the plate by a horizontal line 6¾ inches above the lower border line. This line will form the bottom of the upper three figures. In the middle of the plate, and above this line, construct a rectangle 4½ inches wide by 5¼ inches high, to contain the Greek ornament; and in the spaces to the right of this, and between it and the border lines, construct two rectangles, 5½ inches wide and 5¼ inches high, each ⅝ inch from side border lines, to contain the Roman and Egyptian ornament.

5. To draw Fig. 1 of the drawing plate, the student will first divide the rectangle *a f g h* vertically through the center by the line *x y*, as shown in Fig. 1 of the text, and lay off each side of the line *x y*, $\frac{3}{4}$ inch, marking the points *c* and *d*, and from *c* and *d* to *b* and *e*, respectively, lay off an additional $1\frac{1}{4}$ inches. Through these points *b*, *c*, *d*, and *e*, draw vertical lines through the rectangle. Then, $1\frac{1}{2}$ inches

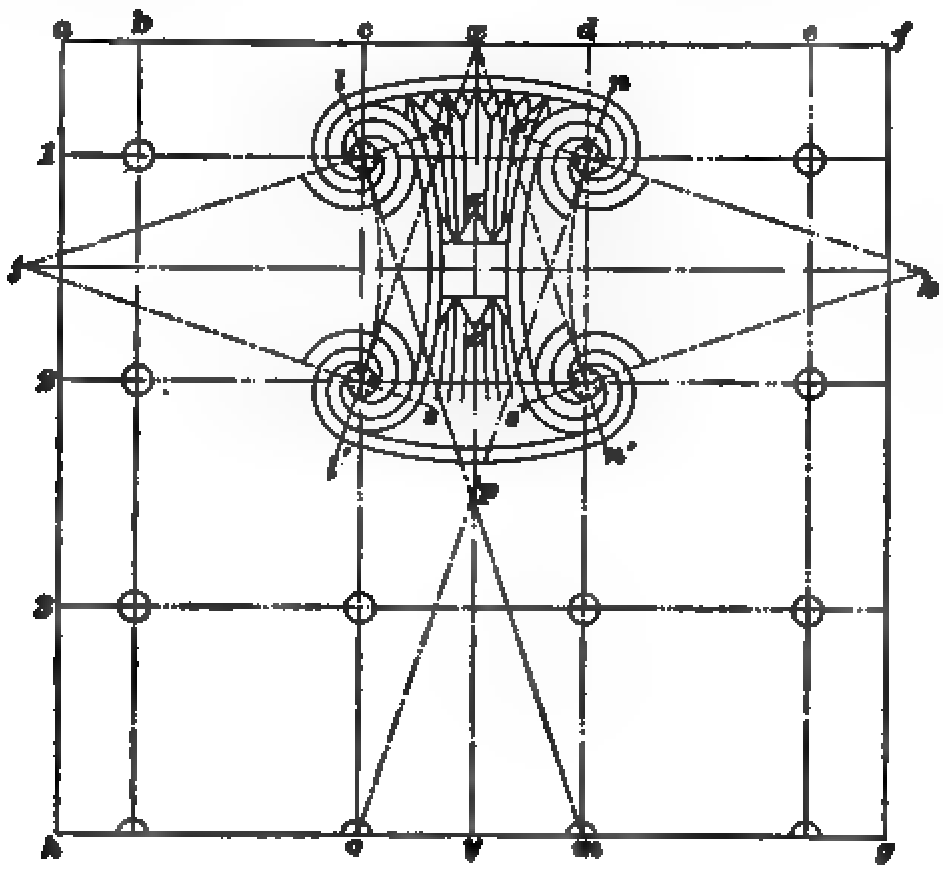


Fig. 1.

below the line *a f*, draw the horizontal line *j k*, and $\frac{3}{4}$ inch above and below *j k*, respectively, draw the horizontal lines *1* and *2*. Then, $1\frac{1}{4}$ inches below the horizontal line *2*, draw the horizontal line *3*. At the intersections of the vertical lines *b*, *c*, *d*, and *e*, and *1*, *2*, and *3*, draw circles $\frac{3}{16}$ inch in diameter; these will be the eyes of the several volutes spaced throughout the design.

From each of these eyes, four individual bands unwind themselves and extend to the four neighboring eyes, while within the space enclosed by these bands a severely conventionalized form of the lotus blossom is to be painted. The curve of the band from one volute to another may be struck

by drawing diagonal lines from the center of any volute to the volute in the next row either side of it and three rows below, as shown by the dotted lines *l m* and *n o*. These lines should be drawn on the plate as guide lines and carried to the points *l*, *n*, etc. on the exteriors of the volutes, $\frac{3}{8}$ inch beyond its center. The point where they intersect at *p* is the center of the arc *l n*.

It will be necessary to draw these dotted lines very lightly from the eye of each volute, as shown, in order to locate the centers and form a proper stopping place for the arcs that join the volute forms. One full set of these lines is shown in the illustration in connection with one section of one figure of the design only, as the repetition of them would tend to confusion. At *x* is the center of the arc *l′ n′*, at *j* is the center of the arc *r s*, and at *k* is the center of the arc *r′ s′*.

6. In order to draw these volutes satisfactorily, it will be necessary to refer to the larger scale drawing shown in

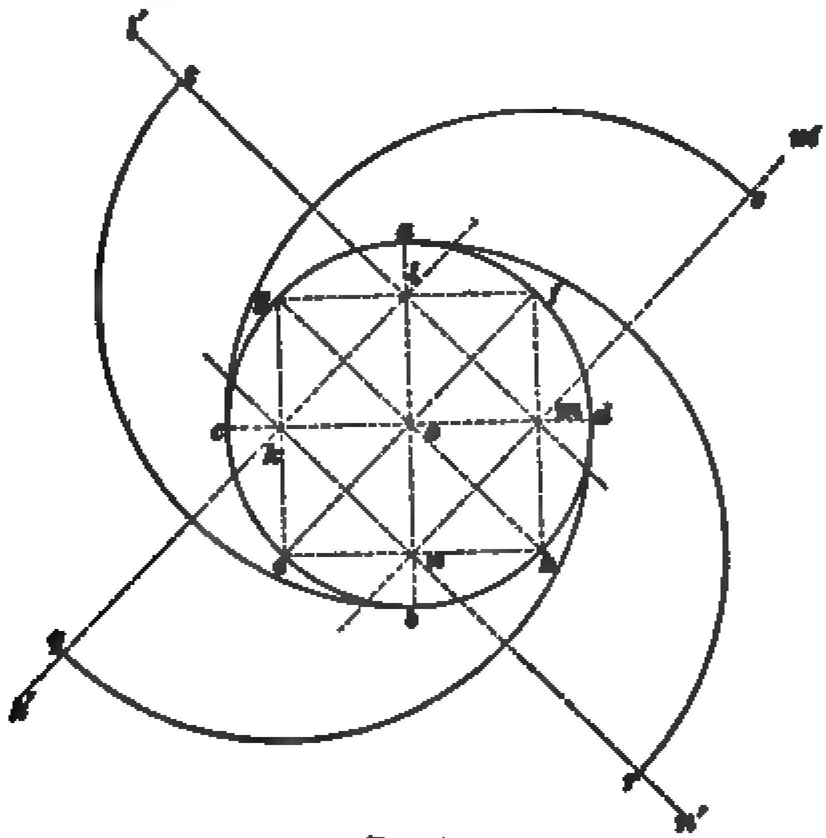


FIG. 2.

Fig. 2 of the text. Here is seen the eye of the volute drawn to a large scale, and the student should now draw it for

practice on a separate piece of paper not less than 1½ inches in diameter, in order to follow out closely these directions. Having drawn a circle 1½ inches in diameter, divide it vertically and horizontally by diameters shown at *a b* and *c d*, and then divide it again diagonally at an angle of 45° by the lines *e f* and *g h*. Construct within the eye, on the points *e*, *g*, *f*, *h*, a square as shown, and at the points of intersection between the sides of this square and the diameters *a b* and *c d*, construct another square as shown at *k l m n*. The corners of this second square will form the centers from which the curves of the volutes are to be struck. The sides of this second square should be prolonged, as shown, to a distance equal to about three times the diameter of the volute, beyond its circumference, as shown at *l k'*, *m l'*, *n m'*, and *k n'*.

7. Now, returning to Fig. 1, we will assume that the eye at the end of the radius *p l* is divided as shown in Fig. 2, and that the diameter *g h* of the latter figure is on the radial line *p l* of Fig. 1, with the center of the volute at the intersection of the lines *c 1* and *d 1* of Fig. 1.

Now proceed to draw the volute by placing the pin point of the compasses at point *k* (see Fig. 2 of text), and with a radius equal to *k d*, to the outside of the eye, draw an arc from the point *d* to some point on the line *l k'*, as *q*, while from the point *n*, and with the same radius, draw an arc from the point *a* to some point on the line *k n'*, as *r*. From the point *m*, draw, with the same radius from *c*, an arc to *s* on the line *n m'*, and from the point *l*, draw from *b* an arc to the point *t* on the line *m l'*.

The centers from which we have drawn these arcs, and the points to which we have drawn them, are shown by the same letters in Fig. 3 of the text. Now go back to the point *k*, where we started, and with that as a center and a radius *k r*, draw the arc *r v*, Fig. 3, and with the center at *l* and a radius *l q*, draw the arc *q w*. With *m* as a center and a radius *m t*, draw the arc *t x*, while with *n* as a center

and $n s$ as a radius, draw the arc $s y$. This brings us back to k from where, with $k y$ as a radius, draw the arc $y z$, and with l as a center, draw the arc $v a$; with m as a center, draw the arc $w b$; and with n as a center, draw the arc $x c$. This completes the voluted form at the intersection of the radial lines $p l$ and $j r$ of Fig. 1.

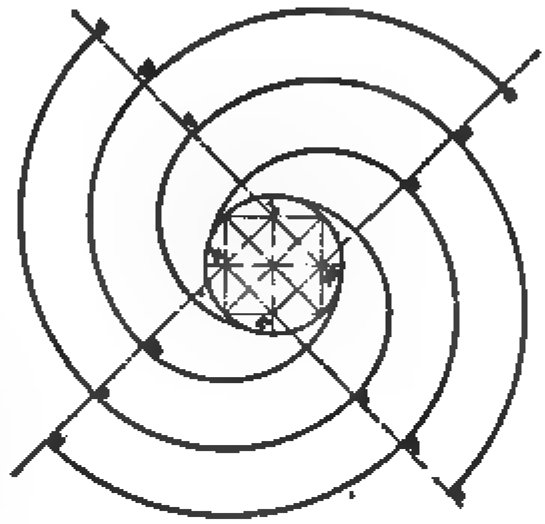


FIG. 3.

8. Another volute at the intersection of the lines $x n'$ and $k s'$ will be precisely like this one, but the two volutes at the intersections of $j s$ and $x l'$, and $p n$ and $k r'$ will be reversed in their direction; that is to say, the lines that are prolonged beyond the sides of the square within the volute will be reversed as shown in the text at Fig. 4. Now, having drawn the volute, shown in Fig. 3 of the text, around the eyes at the intersection of $p l$ and $j r$, and $k s'$ and $x n'$, draw two volutes of the reversed curvature, such as shown in Fig. 4, around the eyes at the intersection of lines $k r'$ and $p n$, and $j s$ and $x l'$, as shown in Fig. 1 of the text.

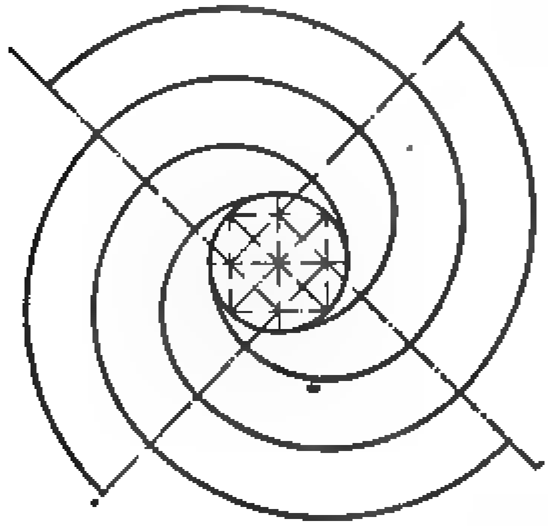


FIG. 4.

The curves joining the ends of these volutes will then be struck from centers at j, x, k, and p with a radius equal to $j r$. This will complete one section of the design, and the others are drawn in precisely the same manner, each fitting into its neighbors as shown on the drawing plate, and forming a completely interwoven composite whole. Observe that every alternate figure, either vertically or horizontally, is

reversed in its direction, the axis of each figure alternating vertically and horizontally.

9. In the middle of the figure just completed, draw a band, $\frac{3}{8}$ inch wide, that shall have for its center line the construction line $j k$, and above and below this band draw the triangular forms suggestive of the antique zigzag shown at z and z'. These triangular forms are drawn with the 30° triangle, and the complete central triangle is about $\frac{1}{4}$ inch wide on its base.

With p and x as centers, lightly draw arcs connecting the centers of the eyes of the volutes, across the space $r r'$ and $s s'$, and divide this arc between the center line $x p$ and the volute at r and r' into four equal parts, as shown. Through these points of division then draw the flaring curved lines from the triangles and z' to the edge of the curve connecting the volutes above and below. The conventionalized petal form of the flower is then drawn at the extremities of these lines with a straight zigzag, and the figure thus completed.

The other figures forming this design must each be drawn in the same manner, and when the entire design is completed, it may be tinted with an India-ink wash, as described later.

10. In Fig. 2 is shown a Greek ornament that approaches as nearly to a repeating ornament as anything we find in the classic styles. The fundamental principle of this design is a rendering of brush work, and the rectangle that contains the design is divided into a number of smaller rectangles, each filled with a figure or device that is reversed and duplicated to produce the whole. Each element or figure composing this design is identically the same as its neighbor, but differs in its relative position. It will therefore be necessary to divide the main rectangle enclosing Fig. 2 by a vertical line $e f$ through its center, and two horizontal lines $j i$ one-third the height of the rectangle above the bottom, and $h g$ the same distance below the top, as shown in Fig. 5 of the

text. Within each of the rectangles so described, a form characteristic of Greek art is described on more or less geometrical lines, and repeated in each of the other rectangles with only such variations as are conditioned by its position. The description of one of these will therefore suffice for the entire lot.

Each figure consists of a heart-shaped device, within which a palmette or brush-work form is inscribed; as the outline of the device is the governing element, we will describe that first. The heart-shaped form finishes at the bottom in two volutes, formed on geometrical lines, similar to the freehand volute shown in Fig. 16 of the Drawing Plate, title, Linear Elements, but, in this case, the volute is dęscribed by mathematical means, and though the construction lines are the same as before, the curves will be drawn by a compass instead of freehand.

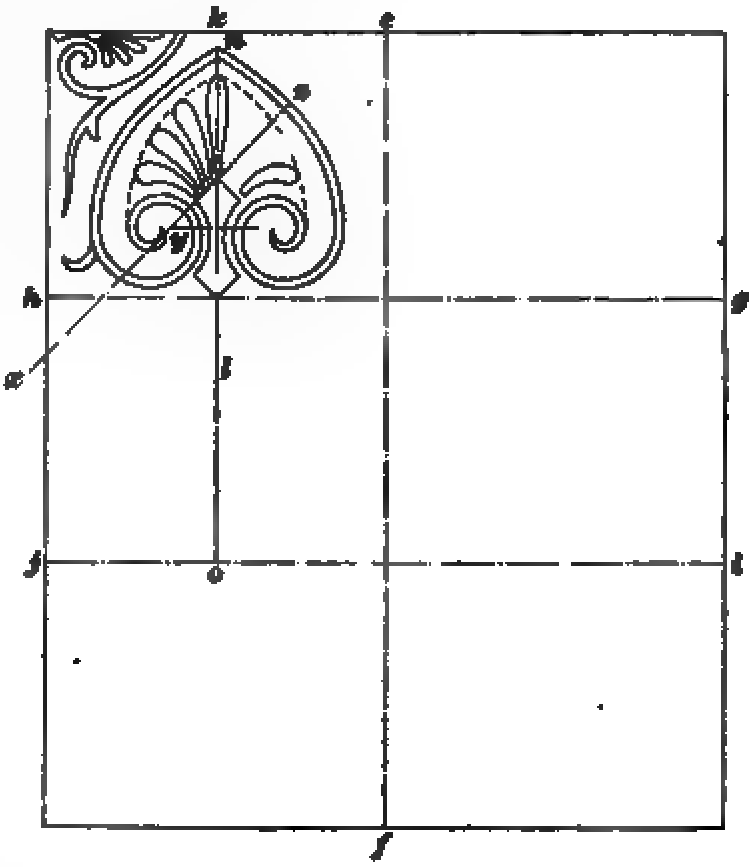


FIG. 5.

11. In order to describe these volutes properly, it will be necessary to refer to Fig. 6 of the text, where the volute is drawn on a larger scale, in order to familiarize the student with its characteristics. Commencing with the upper left-hand rectangle of Fig. 2 on the drawing plate, the student will draw through its center, vertically, the line *k l* (see Fig. 5), and on each side of this line portray half of the ornamental form. Draw a vertical line, as shown at *c d* in

Fig. 6 of the text, $\frac{3}{32}$ inch each side of *k l*, and $\frac{1}{16}$ inch above the line *g h*, draw, to the right and left of these vertical lines, horizontal lines corresponding with *b c* of Fig. 6. From the point *c* then lay out the geometrical construction of the volute, as in Fig. 16, on Drawing Plate, title, Linear Elements; that is, *bc* : *cd* : *de* :: $6\frac{1}{2} : 5\frac{1}{2} : 4\frac{1}{2}$, or by actual measurement *bc* will be $\frac{3}{4}$ inch; *cd*, $\frac{5}{8}$ inch; and *de*, $\frac{1}{2}$ inch;

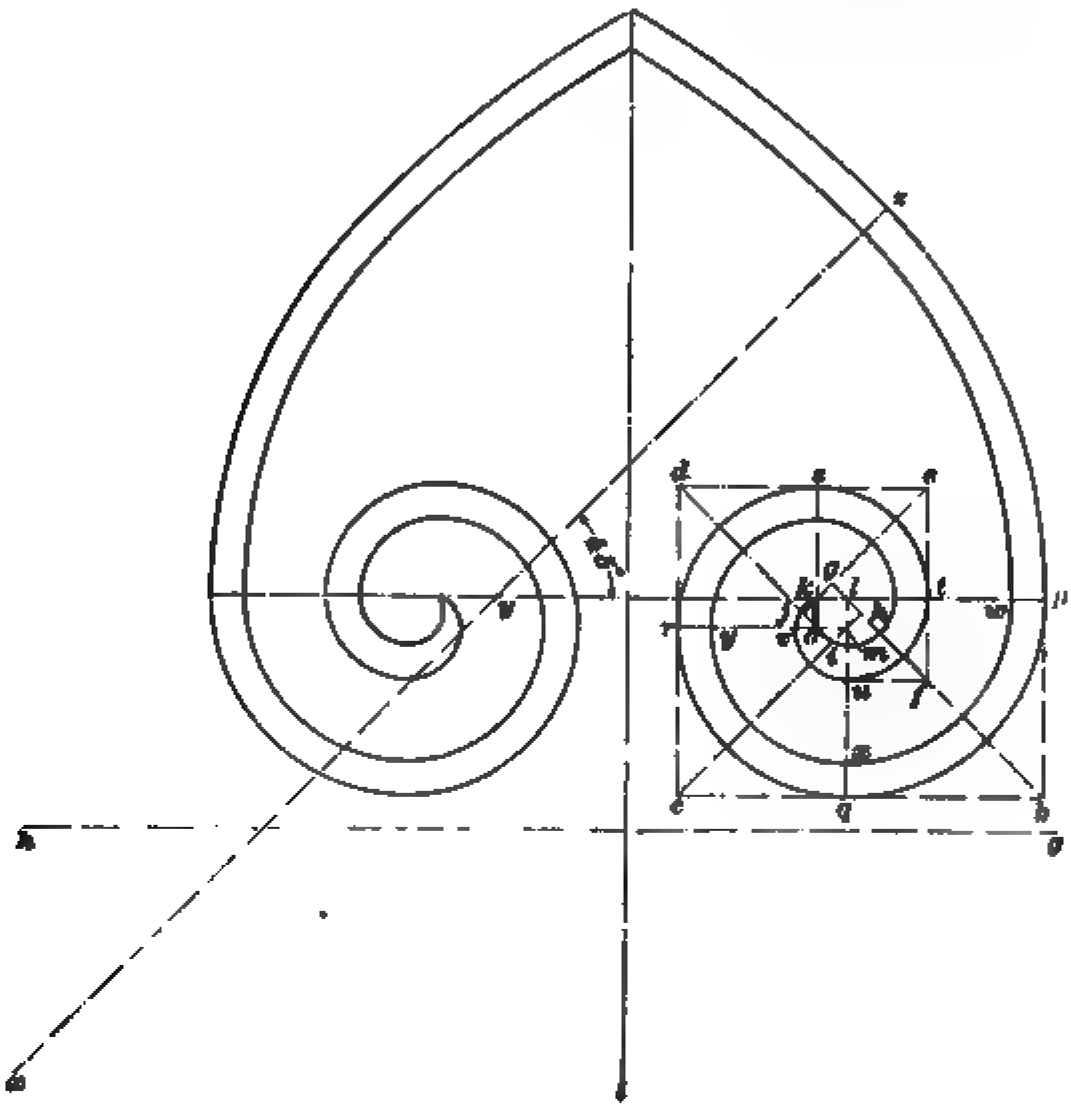


Fig. 6.

ef $\frac{1}{2}(de + \frac{1}{2}\,bc)$, or $\frac{7}{16}$ inch. From the points *b*, *c*, *d*, and *e*, lines will be drawn at an angle of 45°, so as to form, near the center, a rectangle as shown at *g h i j*.

The sides of this rectangle will then be bisected, and within it will be described another rectangle *k l m o*. The side *k l* of the rectangle should be prolonged to *p*, the side

l m, to *q*; the side *m o*, to *r*; and the side *o k*, to *s*. These four corners *k*, *l*, *m*, *o* will then form centers from which the arcs of the volute can be struck.

With *l* as a center and a radius *l p*, describe the arc *p q*; with *m* as a center and a radius *m q*, describe the arc *q r*; then with *o* as a center and a radius *o r*, describe the arc *r s*; with *k* as a center and a radius *k s*, describe the arc *s t*. The arcs *t u*, *u v*, etc. are then described, with one leg of the compass at the same centers as previously used and with a radius sufficient to continue the curve. The inner curve is described parallel to the outer one, the thickness of the band being $\frac{1}{16}$ inch; therefore, with *l* as a center and a radius of *l w*, $\frac{1}{16}$ inch less than the radius *l p*, the arc *w x* is described; and with *m* as a center and a radius *m x*, the arc *x y* is described; and so on to the completion of the interior volute. Then, by curves drawn freehand, the exterior and interior lines of the volute finish in a point at *k*.

On each side of the axial line *k l* in Fig. 5, one volute will thus be described, each like the other, except that they are the *rights* and *lefts;* that is, in arranging the geometrical outline, the line *b c* of Fig. 6 will extend to the left of *k l* on the left of the center line, and to the right of *k l* on the right of the center line, and the point *r* will be, in each case, $\frac{3}{32}$ inch from the line *k l*.

12. The upper part of the figure is formed by placing the compasses at some point on the line *p k*, prolonged in each volute, and with a radius of $1\frac{1}{2}$ inches, drawing an arc from *p* through an angle of 45°, to the point *z*. The center of this arc is marked in Figs. 5 and 6 at *y*, and the radius of the arc is extended from *z*, through *y*, to *x*, a distance of $2\frac{1}{2}$ inches. Now, with *x* as a center and a radius of $2\frac{1}{2}$ inches, finish the arc from *z* to *n*, as shown in Fig. 5. This will complete one half of the enclosing outline in the upper left-hand rectangle of Fig. 2 of the drawing plate, and the other half is formed in precisely the same manner. The interior lines are formed from the same centers as the exterior, but with a radius $\frac{1}{16}$ inch less.

13. The interior of this heart-shaped outline is filled with brush forms, with which the student should already be familiar. The central form is described on the center line *k l*, ⅛ inch below the enclosing outline, and is ⅝ inch in length. Under this, a base is formed with a triangular top, at right angles to which two other brush forms branch, whose under sides conform to the contour of the volutes each side of the center line.

Having drawn the vertical brush mark, sketch from its uppermost point a curved line that will fall each side and become tangent to the volute, as shown by the dotted line in Fig. 5, and then draw the lower brush mark on each side. In the space between the lower brush mark and the vertical one, lay out two other brush marks, evenly spaced, so that the whole will present a palmette form supported upon a base between the two volutes, as shown.

Repeat this operation in each of the six rectangles constituting this figure. In doing this, it will not be necessary to measure and proportion the guiding lines of each volute. Measurements can be taken by means of a piece of paper, on which the center lines and most important parts are marked, and transferred to other sections so as to locate the four centers from which the curves of the volutes are drawn. When all of the volutes are drawn in place, the flatter curves, with the 1⅛-inch and 2⅛-inch radii, can then be described, completing the figures.

14. Where the points of two of these figures face each other, as shown in Fig. 5 at *o*, a small device is interposed in order to fill up the space. This is simply a reduced example of the main figure, measuring ⅞ inch across on its extreme breadth, and ⅞ inch in height, from the bottom of its volutes to the apex of its flatter curves. This latter figure can readily be drawn freehand in each case, although its curves and outline are exactly in proportion to the figure in the larger rectangles.

The brush forms in these smaller figures are also similar to those in the larger ones, and the student will follow the

same instructions in contouring them. There will be four complete outlines of these small figures, and four half outlines, to be executed as shown, within which the brush marks are located, as already described. Short scrolls, each representative of an individual brush mark, are then drawn outside of the figures as shown on the drawing plate, to fill up the intervening spaces, and the design is ready for finishing in color.

15. All of the work so far described in connection with this figure can be executed with T square and compasses, so far as directions are so given, and the outlines of the brush marks may be sketched freehand until a satisfactory contour is attained. Before coloring in, however, care should be given to the entire plate to see that each individual figure is perfectly satisfactory in its pencil outline, in order that the color may be laid evenly and freely. Nothing should be left to be evened up or improved by the brush work, and the pencil outline should be left to govern all of the flow of color.

16. In Fig. 3 of the drawing plate, we have a design characteristic of Roman surface ornament. It must be borne in mind that Roman art was more lavish in its sculpture of surface than was any other style, and while we present Fig. 3 as a typical design of a Roman wall decoration, due regard must be given to the fact that sculptured decoration was far more prominent in Rome than was painted work, and this figure is characteristic of their design in general conception and outline only. It has already been stated that the prevailing characteristic of all Roman ornament was a scroll growing out of a scroll, and enclosing a flower, and that characteristic is fairly portrayed here.

Fig. 3 represents a carved panel, at the center of which is a rosette inscribed within a circle 1¼ inches in diameter, from which floral devices extend in eight directions, each one being thoroughly consistent with the general character of Roman art. At the right and left of the center line are simple conventional designs of the acanthus leaf and blossom,

while above and below extend younger growths of the same plant. In the corners, we find a luxuriant development of the acanthus leaf, flower, and tendril, which is not only characteristic of this style of ornament, but also the predecessor and prototype of a multitude of ideas that were developed during the Renaissance period. In drawing the vertical and horizontal members, the student has but to sketch the simple outline forms, locating each detail by eye measurement; but with the forms extending into the corners it will be necessary to recall some of the instructions given in the conventionalizing of the acanthus leaf.

17. The outline form of the leaf, as shown on this plate, is drawn by means of a series of rectangles, as shown in Fig. 7, and in each of the four rectangles the student will

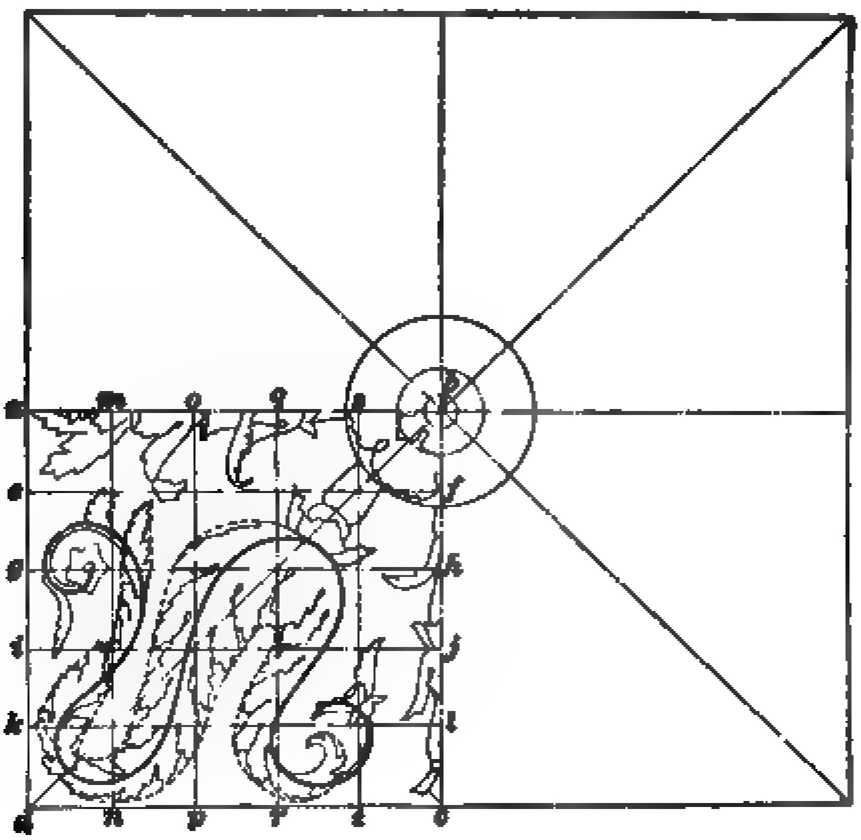


FIG. 7.

lay out the design in the following manner: Divide the rectangle *a b c d* vertically and horizontally into five equal parts, and through these points of division draw vertical and horizontal lines, as shown, thus forming a number of smaller

rectangles. Now observe where the lines of ornament cross these lines and rectangles, and carefully sketch them in on the drawing plate, as was done with Fig. 8 on Drawing Plate, title, Flowers and Conventionalized Leaves. The general outline should be sketched lightly, so that it may be easily erased, until an evenly swelling contour is attained, within which the individual lobes of the various leaves may be described, and the veinings and other markings afterwards drawn. Minor details, such as the tendrils, from which spring the five-pointed flowers, and the side elevations of the blossoms may be left until the entire figure is penciled in, as they are simply inserted to fill awkward spaces, where the absence of detail would attract the eye.

A careful study of the plate, together with the location, by eye measurement, of every element of the design, will enable the student to lay out all the parts with sufficient accuracy. Afterwards he can clean up the superfluous lines, strengthen those that he proposes to use, and prepare the figure for washing in with color.

The rosette in the center contains six lobes, and is too simple to require description. With its diameter known, the student should be able to divide it readily into six equal parts and to complete the device almost identically as shown.

18. Before taking up Fig. 4 of the drawing plate, it will be advisable for the student to study the characteristics of Figs. 1, 2, and 3. It will be observed in the Egyptian ornament, Fig. 1, that the governing outlines can all be laid out geometrically, and that the freehand element is comparatively small; but, though the general design is governed closely by details of the lotus flower, those details are so reduced as to come within the limits of geometrical ornament. This design is the most antique on this plate, and, consequently, we find it more closely allied with the geometrical constructions that are characteristic of all the earliest attempts at ornamental design.

In the Greek design, we still find a geometrical element governing the system, but with no such rigid rules as those

exhibited in the Egyptian example. The volute is laid out on carefully organized mathematical principles, and the enclosing outline of the palmette can be constructed entirely with the compasses; but the palmette itself and the standard supporting it, though influenced by the geometrical contours of their surroundings, are entirely freehand work uninfluenced by any specific form in nature, though typical of the general growth of a particular class of plants. A great contrast, then, is here shown between the characteristics of Figs. 1 and 2. In Fig. 1, a natural type is reduced to purely geometrical elements, while in Fig. 2 geometrical elements are reduced to serve the purpose of a purely natural type or class.

19. In Fig. 3, we have a divergence wherein the skill of execution supersedes the intellectual design. There is no geometry here, except what can be found in the governing outline and in the center lines of the internal figures. Here the artist permits himself to design, within certain limits, a floral form, and to duplicate and reverse it on each side of certain center lines. His work is difficult and requires mechanical skill, but he has not combined the geometrical with the ornamental, nor has he reduced a natural type to a mathematical principle, and his design is therefore wanting in the intellectual simplicity that we find in the two previous examples.

From this it may be learned that the elements of beauty in any design are not complicacy or obscurity, but simplicity, accomplished by a study of the elements entering into the construction.

20. Figs. 1, 2, and 3 represent three stages of progress in the development of design and the history of ornament, and they are the three fundamental stages on which nearly all ornament of the present day is based. The elements of the Greek can be traced to the Egyptian, and the types of Egyptian can be traced in the Greek. Rome conquered Greece and subsequently established her dominion over Egypt, but, in each case, Roman art showed its weakness as

a fundamental style through being conquered by the art of the conquered country.

Egyptian art under Roman dominion was Egyptian in style, though lavish in extravagance. Greek art under the dominion of the Roman Empire possessed its Greek characteristics, though exaggerated in the love of ostentatious display, for which the Roman had such love. Roman art, therefore, possesses no individuality, except in its extravagant voluptuousness and lack of comprehension of the styles from which it grew. It is impossible, in these few figures, to give a full explanation of all these characteristics, but they can be fully comprehended by the student, if, after drawing them and studying their elements, he refers to the discussion of each style in *Historic Ornament*.

21. In Fig. 4 we take up an example of medieval ornament, which can be considered a style that grew from the necessities of its times, and, having outgrown all the influences of its predecessors, was as pure and complete in itself as was the Egyptian. To the medieval artist, Rome, Greece, and Egypt were unknown, so far as their art was concerned; and left to his own resources, he developed new ideas from the same source as did the Egyptian and the savage of remoter times. Geometrical lines and devices at first marked the characteristics of his ornament; these gradually became interspersed with natural forms, both animal and vegetable, while the geometrical characteristics still prevailed. Then, from the eleventh to the thirteenth century, as the crusadal wars brought the medievalist in contact with other nations, he gradually, but unconsciously, absorbed ideas that influenced his work. These helped to reduce it to a rational system rather than to influence the outlines of his forms or his methods of arranging them.

We therefore find the medieval artist perfectly free in the representation, for ornamental purposes, of whatever came under his eye; and whether he portrayed it as earnestly as he knew how, or caricatured it to represent some conventional or ridiculous idea, we can always understand that the motive

underlying the design was absolutely sincere for what the design itself represents.

22. Figs. 4, 5, and 6 rest upon a horizontal base line drawn $\frac{5}{8}$ inch above the lower border line. To draw Fig. 4, construct, under Fig. 1 of the drawing plate, and $\frac{3}{8}$ inch from left-hand border line, a rectangle $4\frac{15}{16}$ inches wide and $5\frac{1}{4}$ inches high, as shown at *a b c d* in Fig. 8 of the text; $\frac{1}{8}$ inch to the right of *a d* draw a line *e f*, and then with the dividers set to $\frac{7}{8}$ inch, space from *a*, along the top line *a b*,

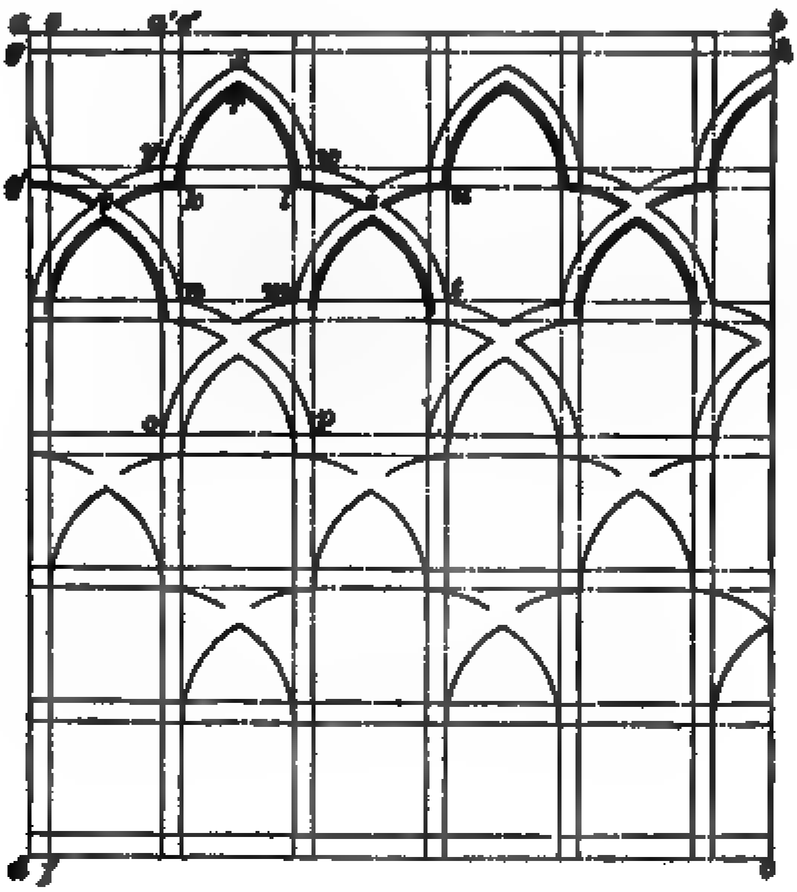


FIG. 8.

equal points $\frac{7}{8}$ inch apart, through which draw perpendicular lines as shown at *a′*, etc.; and on the same line, $\frac{1}{8}$ inch farther to the right, or spaced evenly $\frac{7}{8}$ inch to the right of *e*, locate other points and draw other perpendicular lines as shown at *e′*, etc. Proceeding in the same manner with the line *a d*, draw *g h* $\frac{1}{8}$ inch below *a b*, and, spaced evenly below it, draw horizontal lines in pairs $\frac{1}{8}$ inch between the lines of each pair and $\frac{3}{4}$ inch between the pairs. These pairs of

parallel lines will divide the main rectangle into thirty squares and six half squares, and the intersections of the lines thus dividing it will give the centers for arcs from which the general form of the figures may be struck.

With k as a center and a radius kl of $\frac{1}{4}$ inch, draw the arc lr; and with l as a center and the same radius, draw the arc kr; with m as a center and the same radius, draw the arc ws; and with t as a center, draw the arc us intersecting the arc ls at s; in a similar manner, with n as a center, draw the arc kv. It will be observed that the centers used for these arcs are the corners of the interior square formed by the divisions of the main rectangle, and before the radius is changed to draw the larger arcs, it would be wise to fill the entire figure with the single outline before proceeding further. Then, with k as a center and a radius kw, or $\frac{7}{8}$ inch, draw the arc wx, and with l as a center draw the arc yx; then, with m, n, and t as centers, draw arcs parallel with kv, ls, us, etc.

This will complete the general exterior outline of the figures. The inner border line $\frac{1}{32}$ inch from, and parallel to, the arcs kr, lr, etc. is drawn from the same centers, but with a radius of $\frac{21}{32}$ inch. On account of the minuteness of these dimensions, in order to secure accuracy, the compass should not be changed during the entire operation of drawing each set of arcs of the same radius.

23. These figures, whose outline is based on the pointed arch of Gothic architecture, are then alternately filled with animal and vegetable forms, as shown on the drawing plate. The form of the lion shown in each alternate figure is precisely the same as that drawn in Fig. 11, *Freehand Drawing*, on Drawing Plate, title, Brush Work, and may be proportioned in the same manner. It is only half the size of the one on the drawing plate, however, and all the dimensions given for its previous rendering should be divided by two when drawing it here. The vertical line of the triangle surrounding it and forming a construction line may be drawn $\frac{1}{4}$ inch to the left of the center of the pointed arch on this

plate, when the figure faces to the right, and $\frac{1}{4}$ inch to the right of the center of the pointed arch when the lion faces to the left. Alternating with this heraldic lion in the diaper spaces are the vegetable forms, as shown; these may be readily sketched in place without further instruction than the guide lines in Fig. 8 indicate.

The rectangle containing Fig. 5 of the drawing plate is a square measuring $5\frac{1}{8}$ inches on each side, and is placed with its vertical center line directly under that of Fig. 2. This is an example of Moorish geometrical ornament, and though exceedingly simple in construction, and composed of the most primitive and elementary forms, it is a very complicated and difficult design to draw, as the least inaccuracy of measurement will render it almost impossible to make the parts work out evenly and in proper proportions.

24. In Fig. 9 of the text is shown the principle on which this design is based. Here the rectangle *a b c d* is divided into three equal parts by the lines *e f* and *g h*. On the left-hand side, in the rectangle *a e f d*, we have a simple fretwork design, very similar to some of the Greek compositions, consisting simply of the intersection of a number of straight lines at right angles to each other. In the right-hand rectangle *b c h g* we have precisely the same arrangement of fretwork, but reversed as regards the inclination of the lines; and in the middle rectangle *e g h f* we have a design produced by the intersections and combination of these two arrangements, resulting in a design identical with that of Fig. 5 of the drawing plate. The reduction of the elements of this ornament to their simplest form gives a zigzag line, as shown in Fig. 10 of the text, where the length *a b* is $1\frac{1}{8}$ inches and the length *b c* is $\frac{1}{4}$ inch, and the two lines constituting the width of the outline itself are $\frac{1}{8}$ inch apart and parallel, as shown. The accurate inclination of this elementary form, and the accurate spacing of the lines themselves, so as to be exactly $\frac{1}{8}$ inch apart, is the key to the simple solution of this problem, and the slightest variation in the angle of one or both lines, or the slightest inaccuracy

of the spacing of the lines themselves, will throw the work out so much that the figures composing the design, instead of being regular and identical, will be unsymmetrical and unlike.

The student, in drawing this figure, should observe that the intersections of the right-hand and left-hand details of the pattern take place exactly on the center line *i j*, which

FIG. 9.

should be drawn through the rectangle as soon as the latter is outlined. Then the points *k* and *l* should be located $2\frac{1}{4}$ inches below the points *a* and *b*, and the lines *a l* and *b k* drawn intersecting on the line *i j*. These two lines *a l* and *b k* form the base lines on which are drawn the two series of squares that govern the outline of the geometrical figures, and the entire rectangle *a b c d* should first be divided into a

series of small squares measuring $\frac{1}{8}$ inch on each side and inclining in the direction of either one of the lines *a l* or *b k*. Then complete one full set of figures, as shown by the heavy outlines in the rectangle *a e f d*, and let this set design be carried over the entire rectangle *a b c d*. When these figures are completed, the construction lines should be carefully erased and a second set of squares, inclining in the opposite direction with the line *b k* as a base, drawn in, observing that the intersections of all important lines take place on the center line *i j*.

When the intersections are all carefully drawn in, the guide lines should be erased and the main construction

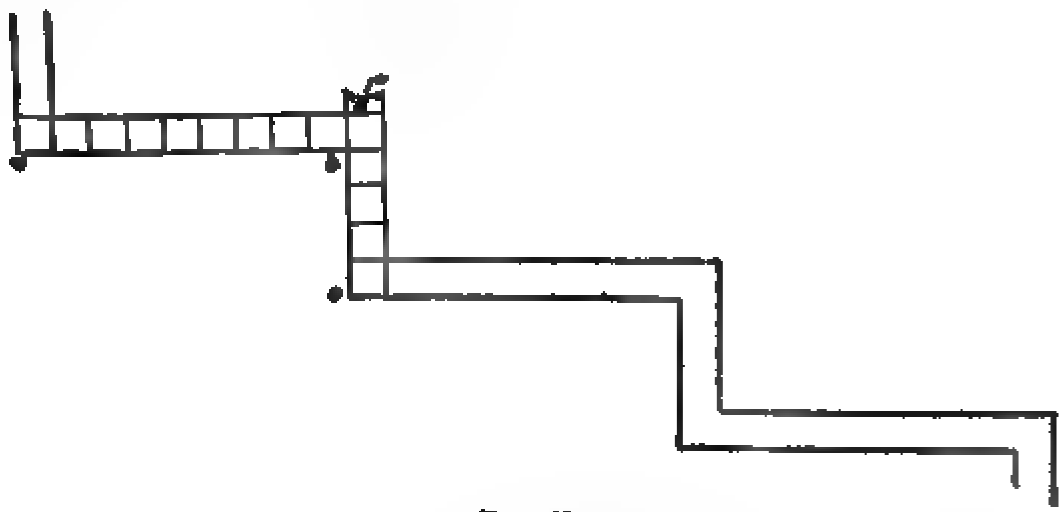


FIG. 10.

lines of the ornament strengthened with a hard pencil, preparatory to the washing in with color. If the student prefers, the outlines may be inked in with a fine line instead of the hard pencil; but before the color is applied, in either case, all vestiges of construction lines should be carefully erased, as they mar the completed design if allowed to remain.

25. In producing this, or any other design based on the intersection and interlacement of two separate patterns, it is necessary to observe that the common points of intersection, as *m*, *n*, and *o*, of Fig. 9, take place on the same vertical and horizontal lines, in order that the finished work may be symmetrical and easy to repeat. A simple way to secure this result is to draw the complete pattern, and then make a

tracing of it and reverse the tracing upon the drawing, shifting its position until a proper angle of intersection with the pattern already drawn is secured. For instance, if the rectangle *a g h d* were drawn out in full, with the pattern shown in the rectangle *a e f d*, and a full tracing made of this and reversed so as to cover the points *e*, *b*, *c*, *f*, the points *n*, common to both original design and tracing, could be located over one another and the two drawings shifted around that point until the angle was secured that would give an exact repetition of the same figure on all sides. This angle, it would be found, would correspond with the one already given, where the distance *a k* is 2¼ inches and the distance *a b* is 5¼ inches.

26. As many kinds of Moorish and Arabian ornament are based on this principle, it will be well for the student to experiment with other forms than this, in producing results, using an elementary line similar to that shown in Fig. 10, but with the angle *a b c* either greater or less than a right angle, or with the lines *a b* and *b c* curved instead of straight. A number of pleasing ornaments based on this principle can be constructed in this manner.

27. Fig. 6 of the drawing plate is taken from a Persian rug, and illustrates the characteristic elements of this style of ornament. As in all oriental art, the colors of the original are brilliant, the general background of the figure having been a dull yellow, against which the blue foliated work showed up very strongly. The corners and the center piece had a background of black and the large floral devices shown scattered throughout the design were white, while all the other blossoms were red, and the fine foliated line connecting the floral devices and blossoms was a pale green, scarcely distinguishable against the ground of yellow.

The outline of this figure is geometrical, as is also the ornament, but it must be drawn almost entirely freehand. The student will therefore construct a rectangle, 4⅞ inches wide and 5¼ inches high, directly beneath Fig. 3 of the plate,

within which to construct the design. The width of this rectangle will be divided into ten equal parts, through which will be drawn vertical lines as shown at *a*, *b*, *c*, *d*, *e*, *f*, etc., Fig. 11, and the height will be divided into twelve equal parts, through which will be drawn horizontal lines, as shown at *1*, *2*, *3*, *4*, *5*, etc.

By locating the essential elements of the ornament as it crosses these lines, the whole figure may be readily described, and the lines of the foliated ornament connected so as to form a continuous design. For instance, the point of the general outline under *f* is on the line *f* about one-third the distance between the horizontal line *a* and the horizontal line *1*, and sweeps to the right and left in a compound curve, so as to nearly strike the line *d* about midway between the horizontal lines *1* and *2*. The interior line is parallel to, and $\frac{3}{32}$ inch from, it. The main lines of the scrolls should be proportioned, in the same way, and then the foliated line from which the flowers spring, and, lastly, the flowers themselves. The foliated device formed in the corners of the rug may be drawn within a circle $\frac{5}{8}$ inch in diameter, whose center is on the line *1*, two-thirds the distance from *b* toward *c*.

FIG. 11.

The five-pointed floral devices that occur within the squares bounded by lines *d e* and *4–5* and on the center line between lines *2* and *3*, may be described within a circle whose radius is $\frac{3}{16}$ inch, while the floral forms near the intersection of lines *e* and *8* may be described within a circle

whose radius is ¼ inch. This information is given in order that floral forms similarly placed may be uniform.

Having drawn this figure in all its details, carefully strengthen up all the outlines, so that they may be readily followed in the subsequent operation of washing in. Clean out all guide lines and again strengthen the outline where it may have become pale through erasure, after which the plate is ready to be finished with brush and wash work.

WASH WORK.

28. Before attempting to wash in any of the details of this plate, it is necessary that the student should have before him a diagram of shades and tints, in order that he may intelligently comprehend the references we make to different gradations of color in this and the next five drawing plates.

29. Making the Diagram of Tints.—Stretch a piece of drawing paper, not less than 8 inches square, upon the board, and on it draw a rectangle measuring 6 inches on each side. Divide this rectangle into thirty-six squares of 1 inch each, and ink in the lines bounding it, and separating the smaller squares, with waterproof ink. Now mix a considerable quantity of water and India ink, in order to lay a *very pale* wash over the entire diagram, and allow same to dry thoroughly; afterwards, a second wash should be applied, but covering only thirty-five of the thirty-six squares of the diagram, and this should be allowed to dry also. A third wash should then be laid over thirty-four of the thirty-six squares, and so on until the entire rectangle has been washed over thirty-six times, each square receiving in its turn one more wash than its predecessor.

These squares should now be numbered, in any convenient way, so that reference can easily be made to any particular tint by its number, that is to say, No. 1 referring to a single wash, No. 10 to the square that has received ten washes, No. 36 to the square that has received thirty-six washes, each of these numbers representing a tint

corresponding to the tint on the reference diagram. This is shown in Fig. 13, though the tints are not all numbered, but those on the border have numbers in front of them representing the number of washes they have received, and the intermediate ones can readily be counted up.

The student will keep his diagram as a reference for all work in this part of the course, and, in preparing same, he is cautioned not to make tint No. 1 any darker than that shown in Fig. 12, nor to attempt to wash over any square or squares until the previous tint laid is thoroughly dry. On

Fig. 13.

this account, it is advisable that the entire 6-inch rectangle should not be covered at one sitting, but allowed to wait from time to time while the student is engaged on other work in order that its result may be thoroughly satisfactory. When it is finished, the student will write his name and class number clearly on the bottom and send it in with his plate

on Historic Mural Detail in order that it may be recorded and criticized as to its quality, etc.

30. Before attempting to wash in Fig. 1, the student will carefully ink in all the lines with waterproof ink and then wash over the entire rectangle with a tint equal in depth to No. 1 of his color diagram. The eyes from which the volutes spring, and the straight bars that connect the convex sides of the long flat curves from the volutes, are tinted to a depth of No. 6 or 7 of Fig. 12, and the portions between the bars and the flat curve of the volute should be tinted to a depth of No. 12 to 14.

It should be borne in mind that it is not absolutely necessary that these shades should correspond identically with those expressed on the original drawing plate, as differences in printing are likely to affect them, but the student must maintain the same relative contrast between adjacent parts, and these contrasts are expressed by the depth of his color in accordance with the foregoing numbers.

It is not necessary, either, that these depths should be obtained by repeated washes on the drawing plate to the number of twelve or fourteen tints, but the color can be mixed to the desired tint and tried with a brush on a separate piece of paper, when, after drying, if too dark or too light, it may be altered by the addition of water, or more ink, as the case may require.

31. In the Greek ornament shown in Fig. 2, the entire surface is washed over as before with the No. 1 tint, without outlining the forms in ink, and the honeysuckle and palmette forms are washed in with a tint equal in depth to about No. 12 or 13, care being exercised to keep this tint perfectly even, in order that one part of the figure may not be darker than another. In order to do this, it is wise to use plenty of color on each detail when the color is first applied and then dry the brush out partially by drawing it across a piece of blotting paper, and removing the surplus color from the drawing with the point of the brush.

Fig. 2 is far more difficult to render with the brush than Fig. 1, though the former has a greater variety of tints, and the student is urged not to hurry his work, as all the preliminary labor of drawing these designs may be wasted through carelessness or hurry in the brush rendering.

Wash over the entire rectangle containing the Roman ornament with one tint of light color, and then strengthen the foliated ornament throughout with a tint corresponding to No. 12. The darker portions of this foliated ornament may then be strengthened with a tint equal to about No. 18, and the eyes in the acanthus leaf, and small loops in the central rosette, may be touched up to a depth of No. 24.

It will be observed in this that the greatest contrast in light and shade lies between tints No. 1 and No. 12, that is, between the background and the lightest of the tinted ornament. This is done in order that the ornament may stand out clearly and sharply against the ground, whereas the other tints are simply shadings of the same material, or, in other words, variations of the ornament itself. This is, in reality, one form of spotting, as we are producing variety by means of a variation of light and shade.

32. The Gothic ornament in Fig. 4 is tinted in three separate and distinct shades, the entire rectangle being washed over with No. 1 tint, and the geometrical figures that form those details of the surface decoration that are without enclosed ornament are tinted to a depth of color equal to No. 6. The heraldic lions are also of this tint, while the background surrounding the foliated ornament in the other geometrical figures is tinted to a depth of No. 12. An emphasizing shade line in No. 12 tint is also drawn in the upper half of each of these geometrical figures after all the other tinting has been washed in and dried.

33. In the Moresque ornament there are but two tints used—a No. 1 tint going over the entire background and a No. 12 tint outlining the geometrical forms characteristic of the design. In colored work, the contrast between the

ground and geometrical figure is established by color, the one usually being black and the other red. Here we arrive at a similar effect by a variation of light and shade.

Each one of these irregular geometrical figures must be colored separately with a small brush, and care must be taken not to go over any figure twice, nor to use a paler or darker shade of ink on one figure than on another, also to have about the same amount of ink in the brush as each one is washed; otherwise there will be a variation of tint between the beginning and finish of the drawing that will be almost impossible to overcome.

34. Oriental Designs.—The Persian design is washed in four tints—a No. 1 tint for the entire background, a No. 7 tint for the curving arabesques of its surface decoration, an intermediate tint for the fine ground line that must simply be indicated rather than clearly expressed, and No. 36, which is practically black, for the background of the corners and the device at the bottom of the figure.

The foliated ornament against this background should be outlined in waterproof drawing ink before the ground is painted in, and if the student so desires, he may outline all of the surface ornament with a very fine black line before applying the color. He will find that the color will flow more readily within the limits of the line than where the pencil is used, but must not let this lead to carelessness in handling, as a spreading of the color beyond the black outline will show much more plainly here than where the line is simply in pencil. Fig. 3 may be also outlined if desired, but care should be taken that the line is very fine and no more obtrusive than that shown in the original drawing plate.

35. Mixing Colors.—In mixing the color for this plate, and particularly for the preparation of the color diagram, it is highly important that sufficient color should be mixed at one time for the completion of any one figure or wash, as a second quantity can never be mixed to match the first

exactly, and the relative color values will appear different. In making the color diagram, be sure that there is plenty of color in the cup and keep the cup covered as much as possible, in order that the water may not evaporate and thus render the washing ink darker.

DRAWING PLATE, TITLE: ARCHITECTURAL ELEMENTS.

36. On this plate are given six examples of ancient architectural ornament, showing the chief characteristics of the entrances, or portals, and of the tops of supports, in the three principal styles. The student is expected not merely to draw these plates according to the directions, but to pay particular attention to each detail as it is explained, and study each figure separately, in order that the characteristics of each style may become impressed on his memory.

As each of these figures is symmetrical on each side of a vertical center line, they will be located on the plate by means of their center lines, and the student should lay off his measurements from the center line only, when it is possible to do so, and not make measurements from lines of the figure itself.

After drawing the border line to enclose a space 13 in. × 17 in., as heretofore, the plate should be divided by a horizontal line 6½ inches above the lower border line, this dividing line being the bottom line of the upper row of figures. Vertical center lines should then be drawn 3⅝ inches, 8⅝ inches, and 13⅞ inches to the right of the left-hand border line. The student may then proceed to draw Fig. 1.

37. Fig. 1 is the front elevation of the propylon, or entrance, to an Egyptian temple. Its massive, single-coursed stones, the severe and unbroken outline, its battering side walls, hieroglyphic decorations, and the winged globe spread out in its cornice are all strongly characteristic of Egyptian art; and it may safely be assumed that the entrance to all

ARCHITECTURAL

Fig. 1.

Fi

Fig. 4

ıL ELEMENTS.

Fig. 2.

Fig. 3.

Fig 5

Fig. 6.

Egyptian buildings of importance was through a portal varying but slightly in its general character from the one shown in this figure.

First, lay out the door opening so that it shall be 3¼ inches high and 1⅜ inches wide, that is, $\frac{11}{16}$ inch each side of the center line. The bottom of the piers each side of the door are 1⅛ inches wide, making the extreme outside points on the ground line 1$\frac{13}{16}$ inches each side of the center line. The entire height of the stonework up to the top of the lintel over the door is 4 inches, and the stonework at the top of the door under the molding measures 3 inches across. The round molding at the top of the lintel is ⅛ inch wide and projects on each side of the doorway a like distance, and the deep concave cornice over this molding is ⅞ inch high to the top, while three-sixteenths of the upper part is occupied by the square-faced fillet, and this fillet is 3⅝ inches long.

38. All these dimensions are shown more clearly in Fig. 13, and the references to the figures of this plate hereafter will apply equally to the drawings on the plate itself and to the outline illustrations of them in the text, the latter being inserted for the purpose of simplifying the description.

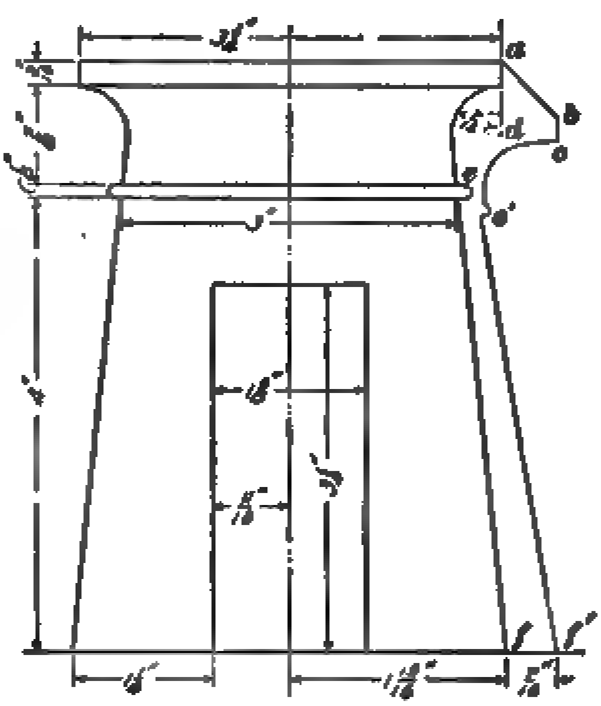


FIG. 13.

The height of the doorway is divided into five equal parts, each one representing a course of stonework, and the horizontal lines drawn to indicate these courses are connected at intervals as shown by vertical lines that mark the vertical joints in the masonry. The first of these vertical joints located should be those at each end of the cornice, inasmuch as the concave cornice and flat stone

at the back of it would naturally be carved from one piece. Two courses below this, vertical joints may be marked in the stonework just under the lintel, while the vertical joints in the course just skipped may be drawn about $\frac{3}{8}$ inch from the joints already located and the other stone-course joints drawn as shown.

The disk of the winged globe over the doorway is $\frac{5}{8}$ inch in diameter and its center is $\frac{5}{16}$ inch below the fillet of the cornice. The outer feathers of the wings spread $1\frac{3}{8}$ inches each side of the center line, while the inner ones extend 1 inch each side. To draw the concave outline of the cornice, take a center on the line $a\,d$, and, with a radius of about $\frac{7}{16}$ inch, draw a quadrant that shall be tangent to the under side of the fillet at the top of the cornice, and to the batter line $e\,f$. Indicate the vertical ribs on the face of the cornice, spacing them about $\frac{1}{16}$ inch apart, and, after outlining the curved edge of the feathered wings, divide them into about eighteen parts, as shown, and with radial lines indicate the feathers themselves.

All these details being located, the outlines of the hieroglyphic characters may be lightly sketched on the stonework, with a hard pencil, and the contour line of the shadow drawn on the wall. The light casting this shadow is assumed to be in front and to the left of the building, so that the light shines at an equal angle in each direction, or 45°. From the corner of the cornice a, a line is drawn at an angle of 45° until it intersects a vertical line $b\,c$ previously drawn $\frac{1}{4}$ inch to the right of the end of the cornice, this $\frac{1}{4}$ inch representing the projection of the fillet of the cornice beyond the wall. The half-round molding below, however, projects only $\frac{1}{8}$ inch from the wall; therefore, on a line drawn at an angle of 45° from e, and at a distance of $\frac{1}{8}$ inch from the line $e\,f$, draw a semicircle representing the shadow of this molding, as at e'. The curved line from c to e' is drawn freehand and represents the gradual decrease in projection as expressed by the shadow between the fillet of the cornice and its lower molding: $\frac{7}{16}$ inch to the right of the pier at the side of the door is the point where the shadow crosses the ground line, this

being the projection of the wall from the bottom, and the line $e'f'$ completes the line of the shadow. This will complete the outline of Fig. 1, and it is ready to be washed in with color according to the directions hereafter given.

39. The student should carefully draw this figure on a separate piece of paper and be thoroughly familiar with each of its details before he attempts it on his drawing plate, because frequent erasing in the latter instance will render it impossible for him to lay his color well, and a little undue haste or carelessness may spoil the entire plate. It is better not to wash in any one figure until all of them have been completed, as otherwise the ink is likely to be unequal in color and therefore unsatisfactory in its results on the plate.

40. Fig. 2 is an example of the lotus capital, with its characteristic polychromatic decoration, as seen in examples of the best period of Egyptian art. The line *a b* (Fig. 14) is 4¼ inches above the lower border line, and extends 1⅝ inches each side of the center line of the column, and the top line of the column neck *c d* is 2⅝ inches above the lower border line. The width of the top of the column across *c d* is 1⅞ inches, and the sides of the column *c e* and *d f* taper so that they would meet on the corners of the abacus, or top block *g h*. This block is 13/16 inch high above the line *a b*, and 15/16 inch wide each side of the center line. The part of the

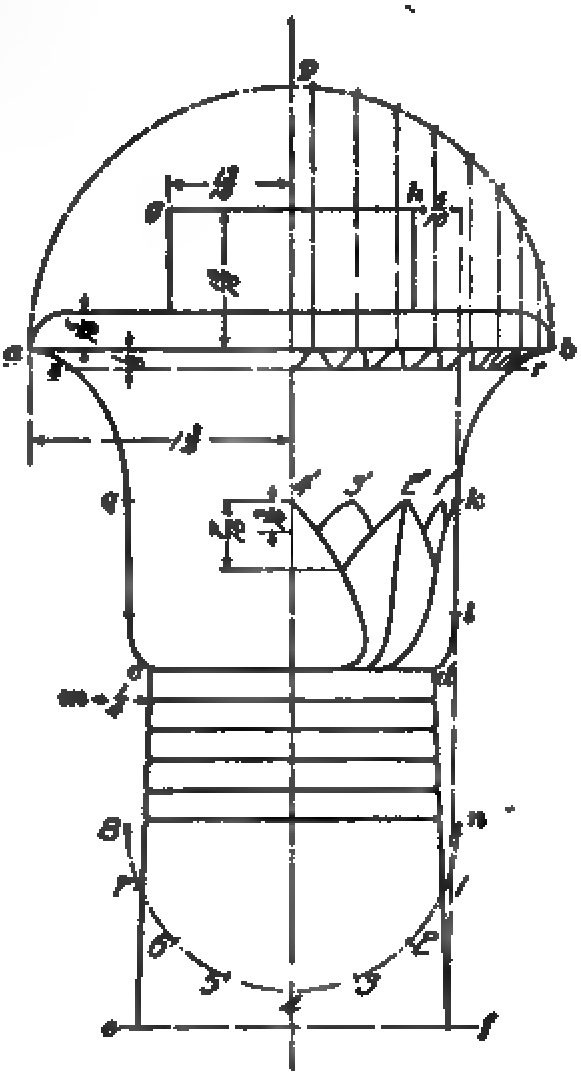


FIG. 14.

capital above $a\,b$ is $\frac{5}{16}$ inch wide, and connected at each side with $a\,b$ by means of a quarter circle as shown. The sides of the capital from b to d are curved, the upper part from b to k and the lower part from d to l being contoured on the curve of an ellipse and the points $k\,l$ connected by a straight line.

To draw the curved outlines of the side of this capital, continue the side lines of the column until they intersect the border line at some point, as f, and from f draw a light line as shown to a point n situated $\frac{5}{16}$ inch to the right of h. The portion of this line between the points k and l will be the straight portion of the side of the capital, the point k being 1 inch below $a\,b$, and the point l, $\frac{3}{8}$ inch above the line $c\,d$. The bands around the top of the neck of the shaft are five in number and measure, altogether, 1 inch; in other words, each band is $\frac{1}{5}$ inch, and the divisions between them at the sides of the column are emphasized by slight, sharp indentations, as shown.

Having thus outlined the column, the student will proceed to outline the decoration, being careful to follow directions exactly, and make his lines very light, but clear and legible, in order that, in the subsequent brush work, he can fill in accurately and carefully, without any blots or blotches due to unnecessary erasing.

41. The character of the decoration on the capital is the conventionalized form of reed work, the lower portion representing in outline the characteristics of the calyx of the papyrus plant, and the portion above this the peculiarities of the blown blossom Each of the rays that appear to grow out of this calyx is found, on close examination, to represent a conventionalized form of the full flower, but are combined in this position to give the general decorative effect of the top of the column.

As the capital of the column is circular in plan, the lines of decoration appear to run closer together toward the sides, and, to locate them properly, it will be necessary to divide the plan of the top of the column into a given

number of equal parts, as shown. In order to do this, a semicircular half plan must be drawn over the top of the column, as shown in Fig. 14 at *a p b*, and divided on the curve from *a* through *p* to *b* into nineteen equal parts, each of which will represent the width of one of the lotus blossoms at the edge of the bell of the capital, and the lines projected from these subdivisions to the line *a b* of the bell will mark the width of each of the upper lotus flowers in the elevation of the capital. The depth of these lotus flowers below *a b* is $\frac{1}{8}$ inch, although their true depth, as painted on the column, is much greater than this, as is shown at the edges, as *b r*. Draw a line lightly at *r s*, $\frac{1}{8}$ inch below *a b*, and then outline the blossoms as shown, turning each one a little more toward the right or left as their outlines approach *b* or *a*, as the curve in the top of the bell shape causes them to lose their perpendicular appearance as they recede from the center.

The ornament shown at the bottom of the bell shape, representing conventionally the calyx of the flower, must also be located by means of a semicircular plan of the column on the line *k q*. This is drawn, for convenience, across the upper part of the column as shown, and its circumference is divided into eight equal parts, as *1*, *2*, *3*, *4*, etc., from each of which a perpendicular line is erected to locate, on the line *k q*, a point of one of the petals of the calyx, as shown at *1'*, *2'*, *3'*, *4'*, etc. on the bell.

42. It will be observed that the extreme outside calyx leaf of the capital and the one in the center under point *4'* are nearly tangent at their lower extremities to the center line of the calyx leaf under point *2'*. If, therefore, we draw under *2'* a vertical line parallel to *k l* and from *l* to the line *c d*, curved to conform to the bottom of the bell, the right side of the center leaf can be drawn as follows: With a radius of $1\frac{1}{8}$ inches and a center at *m* $\frac{1}{4}$ inch to the left of the line of the column, and on a line with the bottom of the first band, draw an arc from *4'* to within $\frac{1}{4}$ inch of *c d*, and then round this arc to conform to the bottom of the capital, freehand. The left side of the extreme right-hand leaf,

whose point is under the point *k*, may then be sketched in freehand, as shown. The leaf under point *2'* is then drawn, extending its sides to the leaves already drawn and touching them $\frac{7}{16}$ inch below the top, and then the little that shows of the leaves under points *1'* and *3'* is located, intersecting the previous leaves $\frac{3}{16}$ inch below the top.

Each one of these leaves consists of fourteen stripes, each parallel to its neighbor and the outside of the leaf, as shown, and the width of the leaf across the bottom must therefore be divided into twenty-nine equal parts—one in the middle for the little lozenge-shaped eye, and fourteen each side, for the stripes above mentioned. The other leaves are similarly striped, although those on the extreme right and left will appear narrower than those in the middle, owing to their altered positions.

A vertical line through the center lotus blossom, corresponding to the center line of the column, will be properly placed for the stem of this blossom, and a curved line at the extreme right and left sides of the capital, parallel to the outline of the bell, will represent in its proper place the stem of the extreme right and left of these blossoms.

Between these extremities, lines will radiate apparently from the top of the column with a greater or lesser degree of curvature, according to their nearness to the outside or the center of the column, and these lines must be carefully sketched by the eye until they are uniform and accurate, and, when equally spaced, the intermediate lines and conventional flowers should be drawn with their stems located by a similar system and in a similar manner, and then the final hair-like appendages alternating with each set of blossoms.

All this work must be carefully carried out in pencil, and, when the capital is finished, the pencil lines should be well strengthened in order that the subsequent washings with color may not entirely erase them.

43. In Fig. 3 is shown a doorway from the Erechtheum at Athens, which is essentially Greek in its design. The

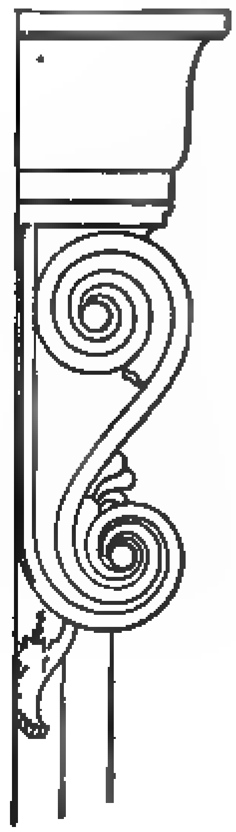
opening in this doorway is to be drawn 2 inches wide at the bottom, and $1\frac{7}{8}$ inches wide at the top, thus showing a slight batter or diminution in width that may have been inherited from the old Egyptian design, though the structural character of this is directly the reverse. The Egyptian battered his wall, to make the masonry wider at the bottom, while the Greek battered his opening to make the opening wider at the bottom. The general effect is the same, giving a feeling of stability by the slight incline of the vertical lines.

The height of the opening from the ground line to the under side of the lintel will be $4\frac{1}{4}$ inches, and the student will thus lay it out, measuring 1 inch each side of the center line for the bottom of the door and $\frac{15}{16}$ inch each side of the center line above for the top of the door, as shown in Fig. 15. The miter lines around which the moldings are turned at the upper corners may be drawn at an angle of 45°, and the width of the architrave or jamb each side of the door opening may be laid off as $\frac{7}{16}$ inch, and returned across the opening at the top the same width, mitering at the corners. Over the top of this architrave is the lintel, or cornice, projecting $1\frac{3}{8}$ inches each side of the center line, and the ends of it beyond the side architraves of the door are supported on two consoles, or brackets, each showing on the drawing plate as $\frac{5}{32}$ inch in thickness.

FIG. 15.

The molding of the cornice is what is usually termed a *crown molding*, and its outline is shown somewhat more

clearly in Fig. 16, the upper part being a compound curve between two fillets and resting immediately upon the brackets. The side elevation of these brackets is shown in Fig. 16 (*a*), and a drawing of them should be made, in order that they may be clearly understood before their front view is



(*a*) (*b*)

FIG. 16.

drawn upon the plate. In fact, it would be better to draw the side view completely as shown in Fig. 16 (*a*) and then locate its front view on the plate by projecting lines across, somewhat after the manner shown.

The line of the shadow may now be drawn $\frac{3}{16}$ inch to the right of, and parallel to, the jamb, until it meets a line drawn at an angle of 45° through the corner of the jamb and console. Another line at an angle of 45° is drawn from the top of the cornice, and as the cornice projects $\frac{3}{8}$ inch from the wall, the end of this line will appear $\frac{3}{8}$ inch to the right of the console. The outline between can then be sketched freehand.

The stonework behind the door opening consists of twelve

courses below the top of the lintel, the next to the last one being $\frac{5}{8}$ inch wide and the other ones equally divided and of equal width. The *pateræ*, or disks, equally spaced around the door, are $\frac{1}{8}$ inch in diameter, and the lines of the moldings on the inside of the door jamb measure, altogether, $\frac{1}{4}$ inch across and are divided into seven members.

44. Fig. 4 is an Ionic capital from the south porch of the Erechtheum at Athens, and its distinguishing characteristics are the volutes and bands of the capital over the top of the column.

To draw Fig. 4, it will be necessary for the student to first draw the volutes of the capital and arrange the other details in conformity with them. The outside curve of these volutes extends 2 inches each side of the center line of the column, and the lowest portion of the volute is $3\frac{5}{8}$ inches above the lower border line. It has been observed elsewhere in this course that these Greek curves are based on a regular mathematical proportion, and the proportions of these volutes are exactly the same as those we have drawn in previous cases, namely: $6\frac{1}{2} : 5\frac{1}{2} : 4\frac{1}{2}$.

The student, having drawn the extreme outside and lower lines of the volute, will now lay out the top line representing the top band across the column $1\frac{5}{8}$ inches above the bottom of the volute. This will represent the depth of the volute as $1\frac{5}{8}$ inches, and as the depth is to the width as $6\frac{1}{2} : 5\frac{1}{2}$, we have the width of each volute as $1\frac{3}{8}$ inches; and as the depth of the inner curve of the volute is to the width of the volute as $5\frac{1}{2} : 4\frac{1}{2}$, we have for that depth $1\frac{1}{8}$ inches. In this way and by these proportions, we are able to lay out each side of the volute as before, and calculations will show that the width of the inner curve of the volute is $\frac{9}{16}$ inch and that each of the other curves is just one-half the corresponding outside member.

45. This may be somewhat more clearly understood by reference to Fig. 17, where the line *a b*, $1\frac{5}{8}$ inches long, represents the depth of the volute; *b c*, $1\frac{3}{8}$ inches long,

represents the width of the volute; *c d*, $1\frac{1}{8}$ inches long, represents the depth of the inner side of the volute; and *d e* is $\frac{31}{32}$ inch long, that is, $\frac{1}{2}(ef + cd)$, *e f* being $\frac{1}{2}(ab)$, or $\frac{13}{16}$ inch, *f g*, $\frac{1}{2}(bc)$, or $\frac{11}{16}$ inch, and *g h*, $\frac{1}{2}(cd)$, or $\frac{9}{16}$ inch. In the same manner, we find *h i* to be $\frac{31}{64}$ inch, *i k* to be $\frac{13}{32}$ inch, *k l* to be $\frac{11}{32}$ inch, and *l m* to be $\frac{9}{32}$ inch. In this way we could go on continuously and wind the volute up in as many convolutions as we chose. Or, if we wished to enlarge it still more, we could draw from *a* to the left a line equal to twice *c d*, or $1\frac{13}{16}$ inches, and so on around.

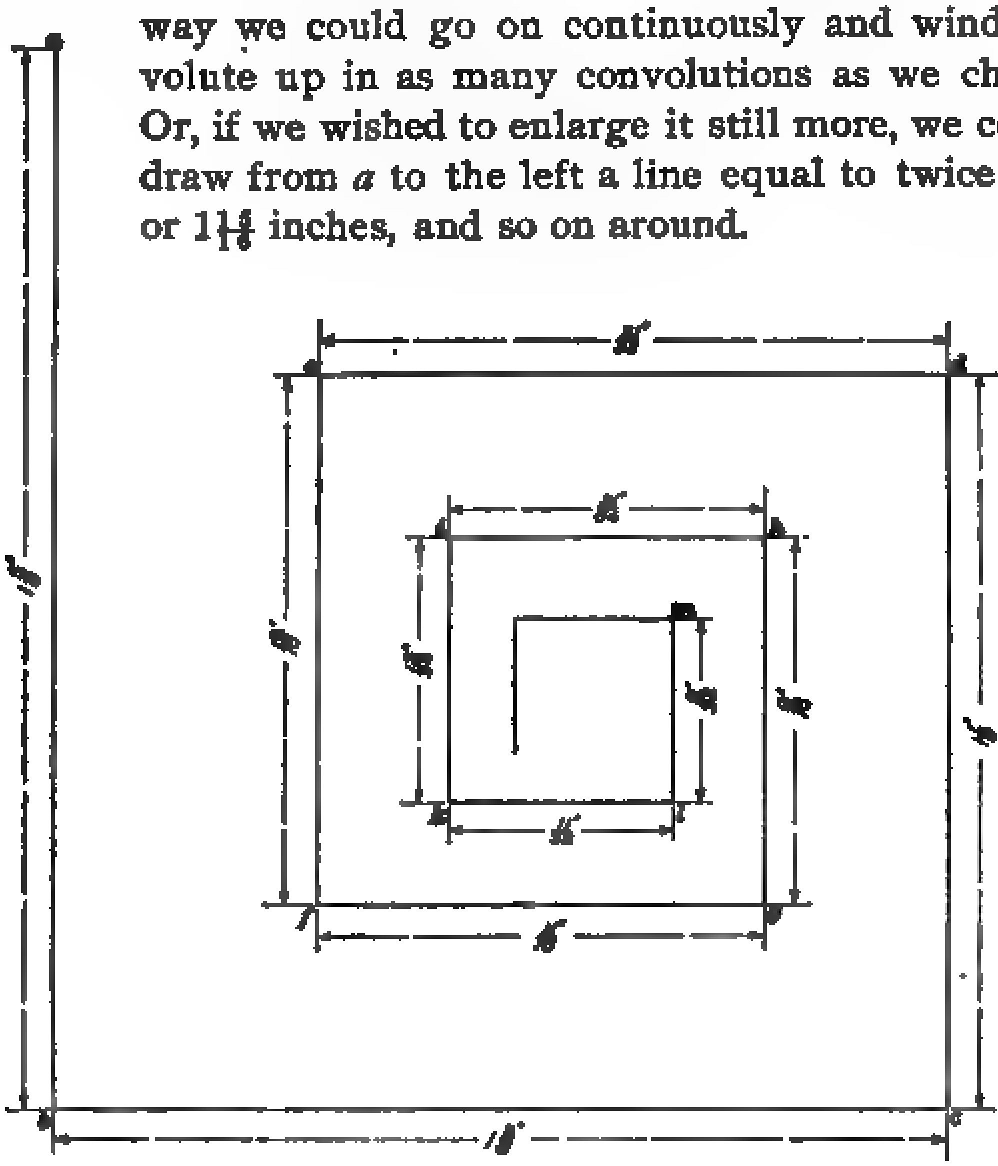


FIG. 17.

From *a*, *b*, *c*, and *d*, lines are then drawn at angles of 45° with the side lines of the volute, intersecting to form at the center a rectangle at *w*, *x*, *y*, and *z*, Fig. 18. The sides of this rectangle are then bisected and the points thus located form the centers of quadrants that are struck to contour the volute. For instance, with *o* as a center, on the line *x z* and with a radius equal to *o–1*, the curve *1–2* is struck. Then

with *p* as a center, on the line *x y* and with a radius equal to *p*–*2*, the curve *2*–*3* is struck, the curve *3*–*4* being struck from *r* as a center, and the curve *4*–*5* from *s*.

We now draw a new set of diagonal lines from the corners *e*, *f*, *g*, and *h*, and form a new and smaller square in the

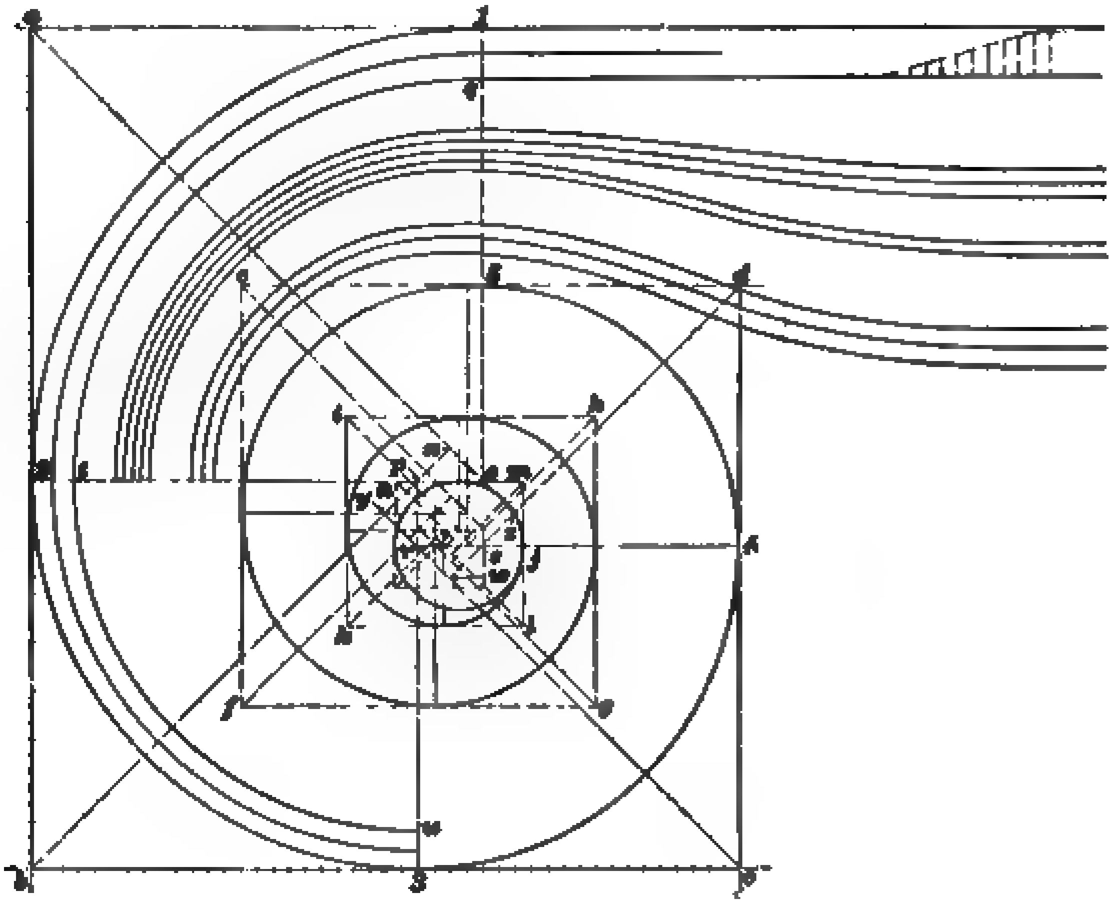


FIG. 18.

center, by bisecting the sides of which we establish centers for the next four curves, and, again bisecting the angles and drawing diagonals from *i*, *k*, *l*, and *m*, we form a new rectangle, from the center of the sides of which we will strike the remaining curves.

46. On this small scale it will be exceedingly difficult, if not impossible, for the student to carry out these instructions exactly, and he is therefore urged to practice them a half dozen times or more on a separate piece of paper before he makes the first attempt to locate the details on his drawing plate. Even then he may find it advisable to contour only the first portion of the volute, that is, the curves

extending through *1*, *2*, *3*, *4*, and *5*, trusting to his eye to complete the rest of them freehand.

Having completed at least this amount of the exterior curve on each side of the center line of the column, the student should draw the side lines of the column so as to make its diameter immediately under the volutes $2\frac{5}{16}$ inches, as shown in Fig. 19, and then draw the band *a* at the bottom of the capital, and immediately above the vertical flutes of the shaft, so that it shall be $1\frac{3}{4}$ inches from the top of the outside volute and $\frac{1}{16}$ inch thick.

From the top line of the volute to the top line of the molding that runs immediately under the volutes at the center of the column is $\frac{3}{4}$ inch, and this molding is $\frac{3}{16}$ inch in depth. The bottom of the egg-and-dart molding between

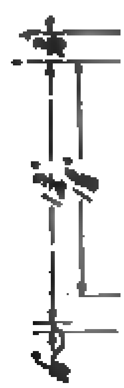


FIG. 19.

the volutes is $1\frac{1}{8}$ inches below the top of the outside volute, and the bottom of the little bead molding below the egg-and-dart molding is $1\frac{1}{4}$ inches below the same point. The

outside band of the volute extends across the top of the column $\frac{3}{32}$ inch in width, and the space from it to the next band below, measured on the center of the column, is $\frac{5}{32}$ inch. The two bands then in the center are each $\frac{1}{16}$ inch wide and $\frac{3}{32}$ inch apart, while a space of $\frac{1}{8}$ inch separates the lower band, which is $\frac{3}{32}$ inch wide, from the second of the middle ones on the center line of the column. These bands diminish in width as they coil themselves up in the volute, the two middle ones uniting to form one band before they have taken the first quarter-turn, as shown at *b*. The location of the bands immediately at the sides of the column as they start to wind themselves into the volute may readily be distributed by eye measurement, as the outer curve of the volute is already determined.

Whether the bands are drawn with a compass or freehand, they should be carried around to the eye with a light, easy, clean line, and the eye itself finally drawn with the compass, $\frac{11}{32}$ inch in diameter and tangent to the last curve of the volute. Its center should be on the side lines of the column.

47. The decoration of the neck, with the horizontal ornament immediately below the ornate portions of the capital, may now be sketched in very lightly, simply to locate positions for various details, as most of this work will be done with the brush or pen after the design is washed in.

The sides of an Ionic column are grooved by twenty-four flutes separated by fillets, and, in order to draw these, it will be necessary to make a half plan of the column and divide it into twelve equal parts, as shown under Fig. 19, projecting each of these parts upwards to locate on the elevation of the curved surface the lines where these flutes will occur. Having done so, the middle fillets in elevation may be drawn a trifle less than $\frac{1}{16}$ inch in width, and the others, in gradually diminishing widths, may be laid out each side according to the position shown on the semicircular plan. In the same manner, the curved or arched finish at the tops of the flutes may be drawn with the compass for the three

center ones, while those on each side, taking an elliptical form as they curve away from the eye, must be contoured freehand.

The abacus or little slab on top of the volutes is $\frac{3}{16}$ inch thick, and extends $1\frac{9}{16}$ inches to the right and left of the center line. Its entire width is divided into sixteen equal parts, each one of which contains the egg molding characteristic of classical art, separated in each instance from its neighbor by a small dart, as shown. The egg-and-dart molding under the volutes is identically the same in form as that on the abacus, but, being carved on a curved surface, the apparent width of these details diminishes to the right and left of the center.

Having drawn all these details of Fig. 4 and strengthened up the principal lines in pencil, the student may now ink in with a fine line the capital and top of the column.

FIG. 20.

48. Fig. 5 of the drawing plate is an elevation of the Arch of Titus at Rome, and is characteristic of the Roman style of architecture. The original arch still stands,

in a somewhat dilapidated condition, in the city of Rome, a monument of past greatness, as shown in Fig. 20.

The width of the arched opening, as shown in Fig. 21, is $\frac{7}{8}$ inch each side of the center line, while the pedestals of the columns each side of it are $\frac{1}{8}$ inch more, and $1\frac{1}{4}$ inches wide in themselves. The moldings below the pedestals,

FIG. 21.

and also the moldings that cap them, project $\frac{1}{8}$ inch beyond the dado, or pedestal line, itself, and the plinths, or square blocks, shown at *a* are directly over the straight sides of the pedestal. The vertical dimensions of these details are all shown in Fig. 21, and the student will follow them carefully in laying out his outline.

The columns themselves are $\frac{1}{4}$ inch in diameter, and their sides are perfectly straight and parallel from their base up to one-third of their height, as shown at *b*; but from this point they taper to the top, where their diameter is only five-sixths of the dimensions at the bottom. The capitals of the columns are simply outline indications of the form shown on the drawing plate in Fig. 6.

Draw all of these details carefully, and ink in the figure with a fine line, then carefully draw the lettering in the tablet above, the style of which is the old characteristic Roman now no longer used, except in its modified form, which modern work titles *French-Roman*. This lettering must be done in waterproof ink or it will run and spoil the drawing plate when the figure is washed.

49. Fig. 6 of the drawing plate is an elevation of the capital of a Composite column, the Composite being the architectural order invented by the Romans for their most

FIG. 22.

luxurious attempts at architecture, and is therefore typical of their character and temperament.

The top of this column should be laid out $5\frac{3}{8}$ inches above the lower border line, and it extends 2 inches each side of the center. The width of the shaft of the column, immediately below the capital, is $1\frac{1}{8}$ inches each side of the center line, and the height of the various details between the top of the shaft and the top of the capital is shown in Fig. 22.

Having drawn the side lines of the shaft, and the fillet and molding shown at *a*, the student will draw the abacus as shown at *b* in its proper position, and then lay out the details of the leaf work of the capital as shown in Fig. 23, where the voluted forms at the angles are shown first sketched in freehand and made $\frac{5}{8}$ inch in depth, as shown at *a*. Then the main leaf forms are outlined in their several positions on the capital, as shown at *b*, and the lower leaf forms are drawn in outline directly over the joints between the larger ones, as shown at *c*, the general size of all these being marked on Fig. 23, which presents about the appearance that the student's drawing should when carried out thus far. The central volutes may then be sketched in roughly, about as shown at *d*, and the outlines of the other leaf forms should be sketched in so as to properly fill the space at *e*.

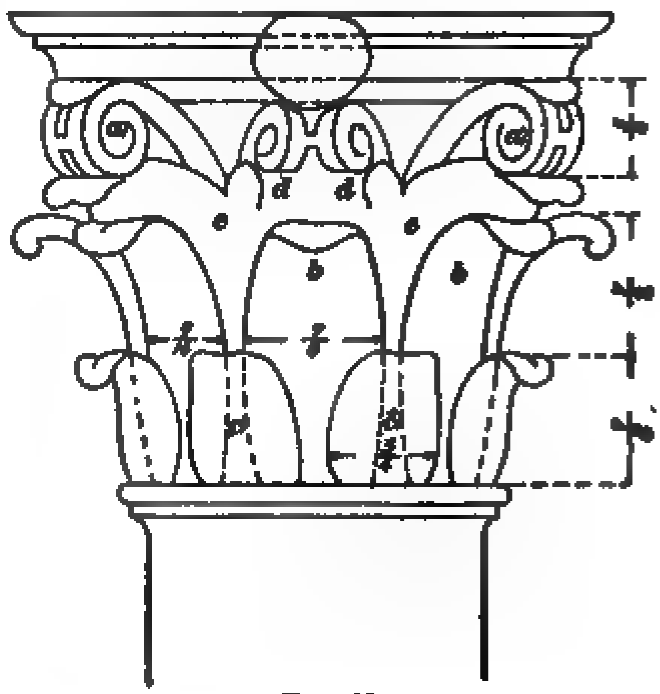


FIG. 23.

50. The lobing of the leaves, the rosette in the center of the abacus, and the small leaf forms over the corner volutes are easily sketched in place freehand by eye measurement, and the student, having arranged the outlines of these to suit him, should proceed to ink in the details before the wash work is commenced.

51. In washing in the figures on this plate, the student will have very little difficulty with either Figs. 1, 2, or 3. Figs. 1 and 3 consist simply of a number of even, flat washes, the whole surface of the figure being covered with a No. 1 tint, and then, for the open part of the

entrance, a No. 24 tint is used in Fig. 1, and a No. 18 tint in Fig. 3.

The shadows of Fig. 1 are then laid in a tint between 7 and 12, but this tint is gradually deepened to the depth of No. 18 as the shadow nears the ground. In Fig. 3, the moldings on the under side of the top and on the left side of the entrance are emphasized as shown, by deepening to a No. 12 tint. Careful study of the original will show about what is required. The outlines of the stonework should not be heavier than No. 6 in Fig. 3, and should be very even in depth of tone, while in Fig. 1, a depth as deep as No. 12 will be permitted and the unevenness both of tint and outline—due to the raggedness required to represent age—should be carefully studied. Each feather of the winged globe, and the right and under sides of the disk and asps, should have a shade line. In expressing the hieroglyphs, they may be outlined very lightly with a fine brush or pen charged with No. 12 or 18 tint, and the left and upper sides should be emphasized in tone to show that the figures are incised and not raised on the wall.

52. Fig. 2 is tinted evenly all over to a depth of No. 1, and the abacus may then be darkened to a depth of No. 6. The middle of the five bands around the neck of the column should be about a No. 4 or 5, and the two adjacent bands may be as dark as No. 12. The shadow on the bell of the capital should be carefully sketched in and then tinted to a depth of No. 12, and the blossoms under the line *a b* may be tinted as dark as No. 24. The right and left sides of the capital should be tinted slightly deeper than No. 1, in order to give the expression of roundness, although this should be a mere suggestion and had better be omitted rather than overdone. Of the calyx leaves at the base of the bell, the outside stripe may be left in No. 1 tint, the second stripe in No. 5, and the fourth stripe in No. 12.

Very little contrast is needed in any of these parts, as the lines are so well defined, and the student may shade in Figs. 1, 2, and 3 at the same time, working from one to another

in order that each may get a chance to dry before it is worked on a second time. The other three figures on the plate, however, should each be treated individually.

53. The entire surface of Fig. 4 should be washed over with a No. 1 tint. The edges of the voluted bands, shown at *c*, Fig. 18, should now be tinted to a depth of No. 3, and immediately below these edges and on their right sides a shadow is drawn to the depth of No. 18, and before the ink of each one of these strokes or shadows has become entirely dry, the brush should be thoroughly rinsed in clean water and the edges of the shadows softened or blended off into the light No. 1 tint that covers the whole surface. This will produce the graded shadows as shown, and give the surface the appearance of being rounded rather than absolutely straight and square.

The student should tint all these details as directed, giving close attention to the original plate after every stroke to see that he has conformed entirely with both the directions and the example before him.

The under and right-hand side of all the eggs and darts in the moldings may then be tinted with a single stroke of the brush charged with color to the depth of No. 7, and the background or body of the column under the darts may be tinted to a depth of No. 12. The point of high light, or, in other words, the lightest portion of the column, is just to the left of the center, and a shadow may be drawn inside of the volute, beginning with the middle one, which should be shaded only to the depth of about No. 4 and deepening, one tint at a time, toward the right and left in order that the outside may be darkest. The band immediately over the volutes may then be tinted to a depth of No. 6, and the shadow of the left-hand volute drawn across it in an elliptical curve, as shown.

Complete all the details as closely as possible to the original drawing, and mark the extreme high lights, where necessary, with Chinese white. This may be done on the upper left-hand edges of the raised ornament on the neck

and on the upper left-hand corners of the eggs in the egg-and-dart molding.

The student is cautioned about using ink of too deep a shade. It is far better to have your ink too light than too dark, as the former can be easily remedied by the application of another wash, while a dark shade must remain the tint it dries, and contrast with it can be produced only by making other tints much darker in proportion.

54. Wash in the entire drawing of Fig. 5 with an even No. 1 tint, and then cast the shadows that are seen to the right of the columns and pilasters in a No. 7 tint. The spandrels, or spaces, immediately above the arch, should be tinted all over with a No. 7, and the shadows shown thereon should be cast in a No. 13 tint. Notice that these shadows make the other portions of the drawing stand out. It shows that the pilasters, marked *c* in Fig. 21, are raised above the surface *d* and that the panel *e* is sunk below the surface *f*. It also shows that the spandrels *g* are so deeply recessed that the column shadow is wider on them than on the surface *h*, where there is only the thickness of the column itself. The small panels between the columns should be tinted, as shown, in flat washes, care being taken to observe the emphasis given the moldings in each case.

Now divide the surface up by lines that indicate the stonework. These lines should be drawn lightly with a brush in about a No. 7 to No. 12 tint. The different stones should then be shaded so as to break the monotony of their surface, and this shading should be executed in a No. 1 tint, repeating same, if necessary, to get a proper depth. Frequent reference to Fig. 20 will aid the student materially in getting the effect he desires in this figure.

55. Great care should be exercised in washing over Fig. 6, in order to keep the tints all light, otherwise it will have a mottled or muddy appearance. An even No. 1 tint is carried over the entire surface to begin with, and then the right side of the left-hand volute is tinted to a depth of

No. 7, while the left side of the right-hand volute is tinted to a depth of No. 4. Toward the left side of the abacus, which is hollow on its face, a No. 18 tint is laid and gradually blended off until at the center of the capital it is as light as the No. 1, thus giving a curved effect. The under side of the quarter-round molding, shown at *c* in Fig. 22, should be tinted to about a depth of No. 18 and rapidly blended off as it rounds out to the surface, while the same molding at *d*, Fig. 22, should be tinted to a depth of No. 12 all over, and strengthened to a depth of No. 24 on its under side.

56. The shadows of the lobes of the leaves at the points where they turn over from the capital should be sketched freehand and then tinted to a depth of No. 7, while all the leaves under the right-hand volute should be tinted to an even depth of No. 7, gradually blending off to the left, the lightest point of the capital being between the middle and extreme left-hand leaves, the left-hand leaves on the edge being tinted to a depth of No. 5 or 6.

The bell or core of the capital, shown at *e* in Fig. 22, is tinted to give it the round effect expressed on the drawing plate, and this general curvature is again emphasized on the moldings below, at *a* where, on the left-hand side, the moldings are tinted to a depth of No. 19 and blended off rapidly to No. 1 over the first three volutes, and deepening again toward the right-hand side until it approaches a full depth of No. 19 again over the third volute from the right and blends off to No. 1 at the extreme right-hand edge. Note all these little details in variations in shading; they are all important and require close study and attention to fully appreciate them.

The little eyes or eyelets formed by the lobes of the various leaves may be expressed in black, and the extreme corners under the volutes and between the volutes and capital may approach very nearly to black, although it is best not to have them entirely so.

This will complete the drawing and washing of the figures on this plate, and the student may draw his border line and

letter the title with his T square and ruling pen. The name, date, and class number and letter should then be placed below, as usual.

There is nothing on this plate that the student is asked to do that he has not already done; it is a very intricate plate to draw, but requires patience, care, and study more than anything else. Each figure should be drawn at least once on a separate piece of paper and entirely finished before it is attempted on the drawing plate, and if the first drawing of it is in any way unsatisfactory to the student himself, he should draw it two or three times before making the drawing plate, as the plate he sends to us is supposed to represent the result of repeated trials during which he has honestly endeavored to do his best.

HISTORIC ORNAMENTAL DRAWING.

(PART 2)

THE DRAWING OF DESIGNS.

INTRODUCTION.

1. Woolen Fabric Designs.—We will now take into consideration the drawing of designs that have been executed, or are suitable for execution, in some woven fabric. The essential difference between a design painted on a wall or carved in stone, and a design woven in a soft fabric, is that the former will always maintain its rigid outline, uninfluenced by any change of position, except so far as that change of position will change the effects of light and shadow. In woven fabrics, however, the goods will frequently hang in folds, thus presenting a portion of the pattern on a convex surface, another portion on a concave surface, and perhaps another portion on a flat surface. Geometrical patterns consisting of straight lines and regular geometrical figures are, therefore, not suitable for this class of work, as the nature of the material will destroy the precision of the geometrical outline. Therefore, broad, bold patterns are necessary in the heavier goods, and more delicate patterns in the fabrics of lighter weight. The importance of these details will be pointed out as we progress with the drawing plates.

DRAWING PLATE, TITLE: TEXTILE PATTERNS.

2. In this drawing plate we have, in Fig. 1, a modern, and, in Fig. 2, a comparatively ancient design showing the variation of motive as expressed in designs for textiles of different qualities. The hard, even curves and well defined outline of Fig. 1 renders it suitable for stamped silk or other light flimsy fabric wherein the surface will be sufficient to preserve the continuity of outline even though the goods lie in folds and irregularities.

Fig. 2 is taken from a damask pattern of the fifteenth century. The peculiarity of damask patterns is that the weave is arranged in such a manner that the figure appears light in color upon a dark ground on one side of the goods, and dark upon a light ground on the other side, making a complete reversal, so far as light and shade is concerned, on the opposite sides. The goods in which this pattern was executed were rather heavy and necessitated a bold, broad pattern, the outlines of which were not confined with any degree of rigidity. The rendering of the floral forms is severely conventional, but not so geometrical as in Fig. 1, and the student will observe that in both Figs. 1 and 2 the relation of pattern to surface has been very carefully studied, there being just sufficient ground showing behind the pattern to set it off and the pattern and the ground so happily arranged that neither seems to predominate over the other.

3. To execute Fig. 1, the student will first draw a perpendicular line 4½ inches to the right of the right-hand border line, and a horizontal line 6¼ inches above the lower border line. From the point of intersection of these two lines he will lay off to the right and left, on the horizontal line, a distance of 2 inches, and above and below the horizontal line he will lay out on the vertical line 3¼ inches. The four points thus located will mark the four angles of a diamond or lozenge shape, as shown in Fig. 1 of the text.

This lozenge shape determines the area of the repeat of the pattern, and the system in which the design is carried out is known as the *drop system* or *drop pattern*, as each

TEXTILE

Fig. 1

E PATTERNS.

Fig 2

element of the repeat of the goods is dropped one-half its height in order to fit the adjacent details, as shown in Fig. 1 of the text. Here the rectangle *b c d e* represents one repeat of the goods in which the pattern is executed, and it will be observed that in order to have the side *c d* match the side

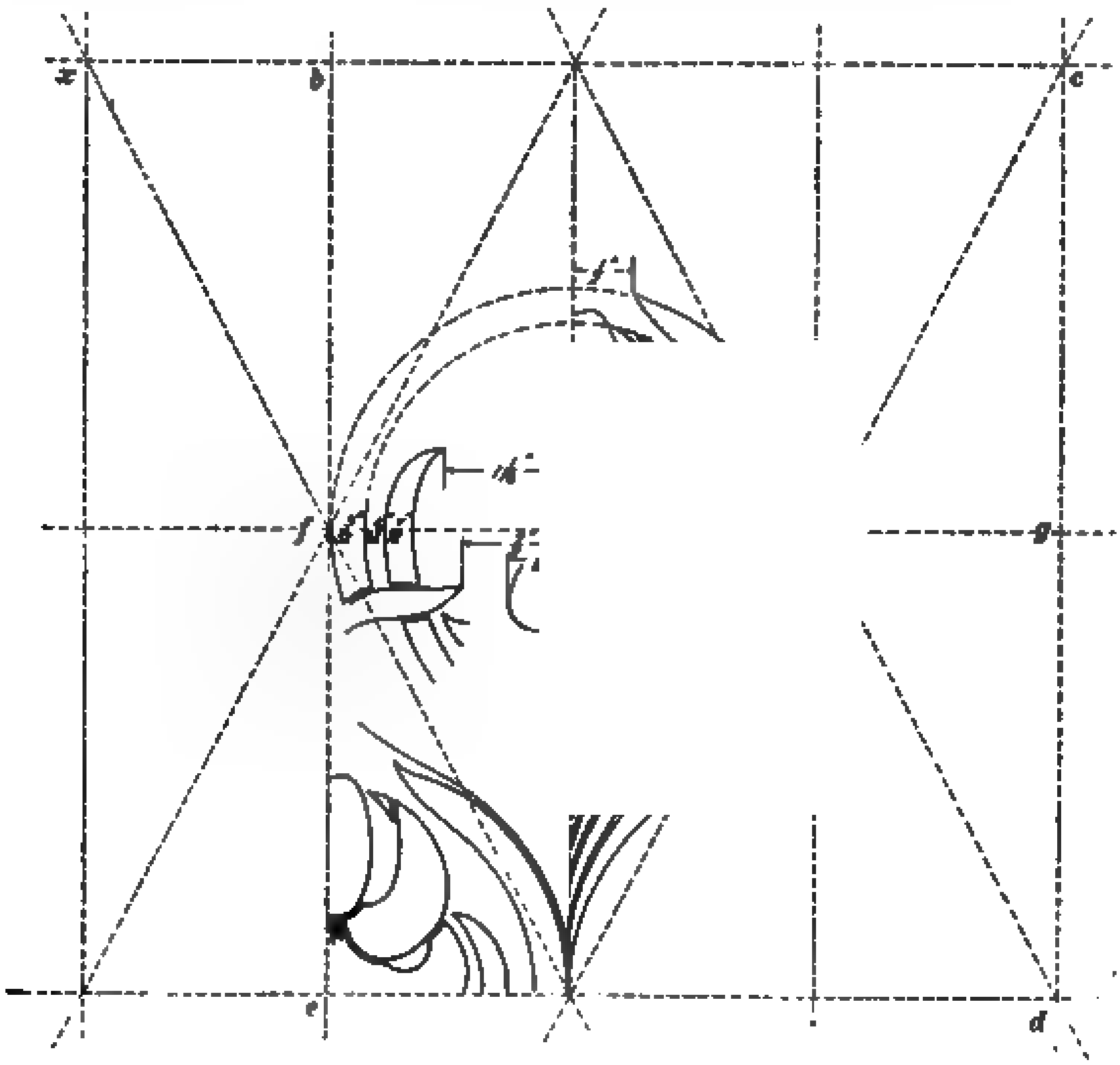


FIG. 1.

b e, it will be necessary to drop the pattern one-half a repeat, so that the line *d g* of one piece of the goods will correspond with the line *f b* of the adjacent piece. For certain classes of goods, such as carpets, wall papers, etc., there is much economy in this system of design.

4. It will be observed from the measurements given in Fig. 1 that the thickness of the two outside leaf blades is $\frac{9}{32}$ inch, while the next ones within are but $\frac{7}{32}$ inch wide at their widest part, and $\frac{6}{32}$ inch from the outside leaf. The

inner and outer curves of the outside leaves are formed on the arc of a circle, as is shown by the dotted line, and the center of this circle is at the intersection of the vertical and horizontal lines just drawn. Other measurements given locate the various parts of the pattern, so that the student should be able to lay it out in pencil without further description. Each of the other lilies in the pattern is enclosed in a diamond shape similar to this one, and they all fit together to form a continuous whole.

5. The student will remember that on Drawing Plate, title, Natural Leaves, he made a sketch in pencil of a plain, straight-standing lily stalk and blossom, and that subsequently on the Drawing Plate, title, Applied Design, he reduced the tiger lily to a geometrical form suitable for embroidery or inlaid work, and in the lily pattern shown in Fig. 1 of this drawing plate he will have little trouble in recognizing the blossom and leaf blades of the lily on the Drawing Plate, title, Applied Design, but arranged in a more constrained manner so that the pattern can be made to repeat in all directions.

6. While it is desirable that the student should get these drawings as accurate as possible, it is not intended that he should follow these dimensions exactly. The main object to be attained here is the production of a design that will repeat in all directions, without any humoring of details to fit at the edges, and if the student should vary the proportions of this pattern somewhat—if his leaves should extend farther beyond the diamond shape than they do in this example, or if there is a contraction in some of the parts, no consideration will be taken of it against him, so long as the general relation of background and pattern remains unimpaired, and the various lozenge shapes are so maintained that any one will fit any other, that there may be no variation in the repeat. In drawing this plate, any one of the lozenge shapes may be drawn first, but it is best to locate the positions of all of them at one time so as to avoid subsequent errors.

7. Each detail of the pattern may be sketched in pencil, and it will be observed that the key to the whole situation lies in the curve of the large outside leaf blade as it comes up over the lily. The convex side of this curve not only fills a portion of the space in the next lozenge shape but it also establishes the degree of curve for the bottom of itself; that is to say, the curve of the top of the large leaf blade governs the curve of the bottom of the large leaf blade next above it, and indirectly influences the curves of all the other blades, which are spaced simply to fill the void satisfactorily.

The short brush strokes shown at *a* in Fig. 2 represent, conventionally, the turning over of the leaf or blade, and in sketching them preparatory to outlining the figure for inking in, the student should bear the fact in mind and represent them as shown in Fig. 2. He will then avoid any distortion that might occur if he simply considered each of them as individual strokes and not as parts of another leaf.

FIG. 2.

When this is all sketched in, the student should carefully cover over this half of his drawing plate with a piece of paper, to protect it, and proceed to draw Fig. 2, after which both can be washed in and tinted with opaque color, as described hereafter.

8. The center line of Fig. 2 is 4½ inches from the right-hand border line, and the design is planned on what is known as a *turn-over* pattern; that is to say, the pattern is symmetrical on each side of a center line, and only one half of it would need be worked up in the design, the weaver being able to arrange the loom so that it will weave the pattern symmetrically to the right and left of the center line.

9. In Fig. 3 of the text is shown the rectangle *a b c d* within which one complete element of the repeat may be drawn. It will be observed here that this pattern does not "drop," as in the previous plate, as the rectangle constituting its repeat is arranged so that the bottom continues over

the top, and the right side is the reverse of the left side of the pattern without extending horizontally beyond the limits of the repeating rectangle.

The pattern thus virtually resolves itself into a stripe, inasmuch as it is continuous and interwoven vertically but independent and separate from any overlapping in a horizontal direction. In fact, such is the case, and the effect of stripe in the woven goods may be materially increased by increasing the scale of the repeating rectangle in a horizontal direction, without increasing the scale of the enclosed design, thus leaving a broader ground space between the elements of the stripe. The effect of this treatment can be seen in Fig. 4, where the pattern is shown on a reduced scale in order to get the effect of three widths, while in Fig. 5 the scale of the rectangle is increased as suggested

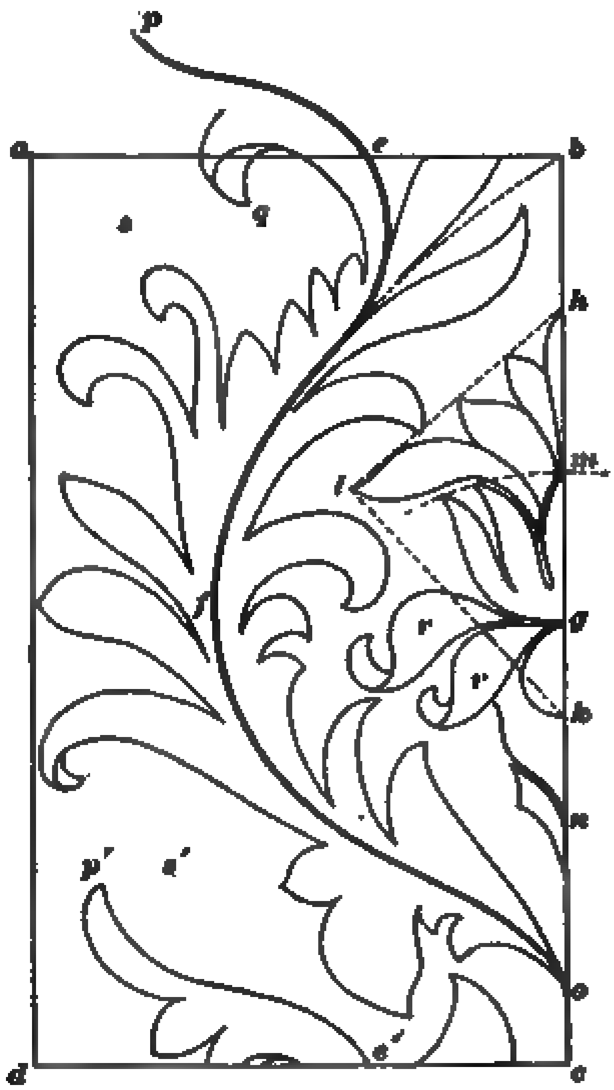


FIG. 3.

Fig. 4.

Fig. 5.

above, and the effect of stripe thereby emphasized. If it were desired to produce this design as an *all-over* pattern so as to avoid this effect of the stripe, it could be accomplished

FIG. 6.

by making it a *drop* pattern, as shown in Fig. 6, where it has been necessary to change the governing line of the pattern but slightly in order to make it conform to the new conditions.

10. To draw Fig. 2, the student will construct on each side of his center line a rectangle $3\frac{5}{8}$ inches wide by $6\frac{1}{8}$ inches long, the bottom of which will be $3\frac{3}{16}$ inches above the lower border line. These two rectangles will each represent one repeat. In Fig. 3 of the text is shown the left one of these rectangles with the design sketched in. It will first be necessary to draw through the rectangle the parent stem or guiding line *o f c*, the point *o* being about $\frac{1}{2}$ inch above the point *c*, the point *f* about half way up the height of the rectangle, and $2\frac{3}{8}$ inches from the line *b c*. The guiding line

then curves in toward *b*, as shown by the dotted line, but reverses its curve and passes out of the rectangle again at *e* $1\frac{1}{16}$ inches to the left of *b*. It is well to continue its course beyond the rectangle, because that will give us the location, direction, and contour of the line *e′ p′* in the lower part of the rectangle, *e′ p′* being the same curve as *e p* beyond the rectangle at the top.

These dimensions have not been given exactly, because this is essentially freehand work and we do not wish to give the student directions for copying this design, but rather to instruct him how to execute a design of this character and at the same time to preserve his own individuality.

11. The parent stem or guiding line *o e* being drawn, the student will roughly outline on each side of it the foliated forms as shown. In doing this, he will observe that there is no material difference between the sketching of these foliated forms and the sketching of the forms for the brush strokes on his Drawing Plate, title, Brush Work. These general outlines are simply the outlines of brush strokes, and the points at *q* show in a general way the appearance of a brush-stroke leaf after it is turned over and shows its under side.

12. The floral form in the center of the design may be drawn within a kite-shaped figure shown by the dotted lines *h l k*, the point *h* being about 1 inch below the point *b*, and the lines *h l* and *l k* being $1\frac{7}{8}$ and $2\frac{1}{8}$ inches in length, respectively, and the angle at *l* a right angle. The petals of the upper part of the floral form are brush strokes, the points of which are all in contact with *l h*. The brush strokes of the lower part bear little relation to the line *l k*, but are governed on top by the arc of a circle whose radius is $2\frac{1}{4}$ inches and whose center at *n* is $1\frac{1}{4}$ inches above *c*. The lower strokes shown at *r* are drawn to fill in the space between the main feather-like stem and the central figure.

13. Having drawn this form complete, it will next be necessary to notch the edges of the foliated forms and reduce it to the conventional outline shown in Fig. 2 of the drawing

plate. The process of doing this is precisely similar to the process in the drawing of the acanthus leaf on Drawing Plate, title, Flowers and Conventionalized Leaves. You have here the general lobe forms to be notched into finer forms, as you had in the previous case, and, by repeatedly referring to your drawing plate, you can study all the detail that will be developed in the final rendering.

14. The foliated forms occupying the spaces at s and s' may be sketched in after the rest of the work is complete, as their only function is to fill the space that would otherwise exist above and below the leaf $e'p'$. The parts of the figure above and below this repeat, as shown on the drawing plate, represent simply the continuation of the pattern above and below, and so far as they show, they are precisely similar to the part already described.

Having completed the drawing, the student will proceed to wash in and tint the plate as follows:

15. After carefully outlining all details of the two figures, the paper should be thoroughly cleaned with a soft rubber and the figures strengthened with a hard pencil so that the first wash may not so remove the pencil lines that they will be indistinct or invisible. If there are any parts of the plate that are inclined to be in the slightest degree greasy from the hands, it is well to sift a small quantity of powdered chalk on the plate and rub it into the paper, in order that the color will flow evenly.

16. Mix a considerable quantity of ink (not waterproof) and water in a cup and have it so diluted that a wash of it, when dry, will be no darker than tint No. 1, of Fig. 12, *Historic Ornamental Drawing*, Part 1. With this pale tint, wash evenly the entire rectangle of Fig. 1 and Fig. 2, being careful not to carry the wash over the edges, but to spread it evenly from the upper left-hand to the lower right-hand corner in a flat wash. Use the largest and softest brush that you have, but not a Japanese brush. Dip the brush into the color and apply it repeatedly to the drawing plate, until

quite a puddle of color is in the upper left-hand corner of the rectangle, as shown at *e* in Fig. 7. The board should be tilted somewhat so that the corner *a* will be the highest and the corner *b* the lowest; and the brush being repeatedly dipped into the color, should be drawn in a slightly curved line under *a*, as shown by the dotted lines, thereby extending the wash gradually toward the corner *b*. If the brush is not large enough to carry the entire puddle across from the side to the corner, as shown by the dotted line from *c* to *d*,

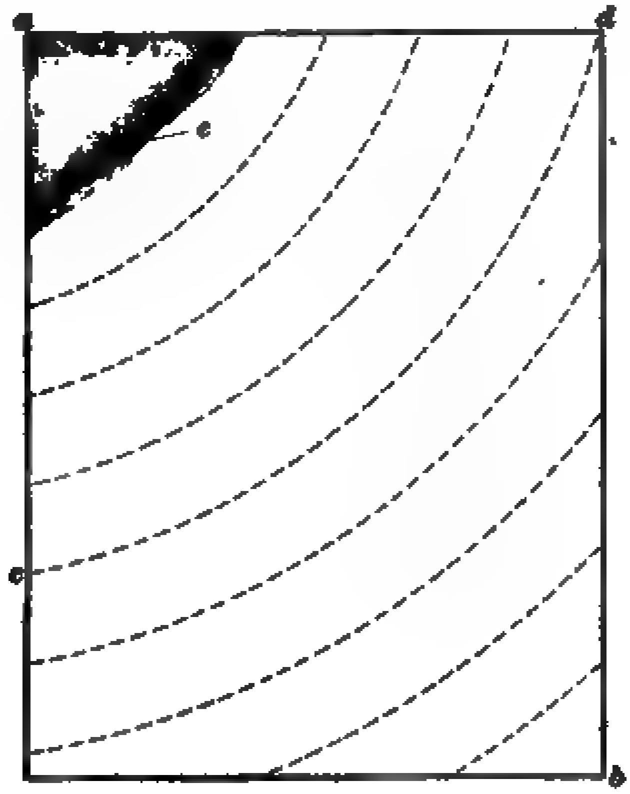


FIG. 7.

it should be dipped into the cup and drawn part way from *c* toward *d* and then dipped again and drawn from *d* toward *c*; but the line *c d* must have a long puddle of color at the bottom of it in order that the tint may be even. Repeat these curved strokes until the wash is carried all the way down to *b*, and then drying the brush on a piece of blotter, tilt the drawing board still more and remove the surplus color as it flows down into the corner *b*.

There is nothing difficult about this, the main points to be observed being that the portion of the plate that dries to form the tint must be drained, not with the brush, but by

the inclination of the board. This drainage can take place very slowly, thereby avoiding streaking, by keeping the inclination of the board less than 30 degrees. If the inclination is too steep, the color is liable to run in a streak down to the corner *b*, whereas if it is not enough, it is liable to settle and become speckled. With the edge of the drawing board against the table, it can be tilted slightly when the wash is laid on and flattened out somewhat while the brush is being dipped into the color.

17. Having completed the wash over both rectangles, the plate should be allowed to dry thoroughly, as no attempt should be made on the next work if there is the slightest sign of dampness in the paper. The figures are now laid on the ground in opaque color, or "distemper"; that is to say, in body color with which Chinese white, or other white pigment, is mixed, so that the color ceases to be transparent. The reason for this is that, owing to the slowness of working over such minor details as are exhibited in the various elements of this plate, the color would be streaked and the drawing uneven if we depended on transparent washes.

18. Mix a quantity of Chinese white in a saucer or shallow teacup until it is about the consistency of thin mucilage. To this add a small drop of ox gall and a few drops of drawing ink (not waterproof) to give it the desired tint; stir it thoroughly until the color and fluid are incorporated evenly throughout the whole, and then try it with a brush on a piece of paper. It will dry out very much lighter than it appears when first applied, so allow the trial application to dry thoroughly before you make up your mind to apply it to your drawing plate. If it dries about as dark as No. 12, of Fig. 12, *Historic Ornamental Drawing*, Part 1, it will do, and you may paint in the body of the figure on your plate.

19. The white lines between the brush strokes, as shown in Fig. 1, must all be left when the color is applied and no

Chinese white used anywhere on Fig. 1 except for the stamens in the center of the lily. If after the entire plate is finished there are a few points where the color has run over on portions that should have been left, a little clear Chinese white may be laid over the damaged part, which, when it is dry, may be tinted with the very palest suggestion of wash in order that it may match the background.

20. In Fig. 2, however, the veining of the leaves is so intricate that it would be practically impossible to leave the ground to show for them, and they may be drawn in with a pointed brush, using Chinese white tinted with a pale wash of ink until it corresponds in color with the ground. Many of the regular lines, however, such as the petals of the calyx in the central figure and the points where the serrated edges of the leaf forms lap over other leaf forms, may be easily and advantageously left the color of the ground when the work is painted in.

21. If the distemper color has at any point run over the outline of the figure, the best way to remove it is by a gentle scraping with a sharp knife. If the wash has run over the edge of the rectangle, it may be removed with an ordinary ink eraser, first protecting the drawing surface itself with a piece of ordinary writing paper, along the edge of which the eraser may be applied so that it does not rub out where erasure is not required. Do not attempt to erase any part of the work, however, until the entire plate is finished, as the application of an ink eraser to the paper will render it porous, and when ink or color is applied it will spread into the pores of the paper to such an extent that it cannot afterwards be eradicated.

The student will now place the title at the top of the plate, as shown, in letters $\frac{5}{16}$ inch in height, the outlines of which may be drawn with triangle and T square after they have been sketched in pencil. The name, and class letter and number, and the date on which the plate is finished may then be placed in their respective corners, as usual.

DRAWING PLATE, TITLE: CERAMICS AND LEATHER.

22. In this plate are given six characteristic designs each illustrating an example of a natural form applied to some specific purpose. Figs. 1 and 2 are plate borders suitable for designs in chinaware, although with slight modifications they are equally applicable to fan borders. Figs. 3 and 4 are designs in stamped-leather work executed as book covers, and Figs. 5 and 6 are also stamped-leather work in designs for wall decoration.

The style of Fig. 1 is Arabian, and the connection of this pattern with a natural form can be easily traced by a reference to *Elements of Ornament*. In fact, the theme of this design is based on identically the same type as that illustrated in *Elements of Ornament*, the only difference being its elaboration in order to make it more suitable to its present purpose.

23. To draw Fig. 1, the student will strike a semicircle whose radius will be 2¾ inches, and whose center will be 3½ inches to the right, and 3⅝ inches below the border line. This semicircle may be divided into eight equal parts by

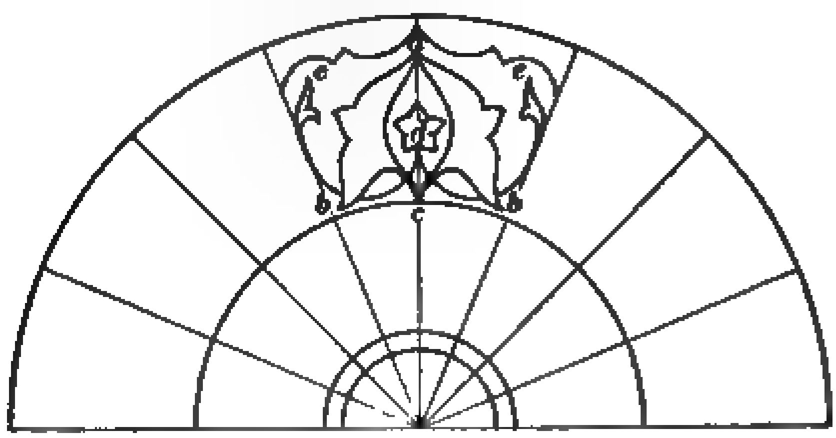


FIG. 8.

lines radiating from its center, as shown in Fig. 8. Beginning with the center one of these lines and then with each alternate line to the left and right, the student will draw the general outline of the foliated form as shown at *a b c* in Fig. 8, the point *a* being 2½ inches from the center, and the

CERAMICS AND LEATHER.

Fig 1

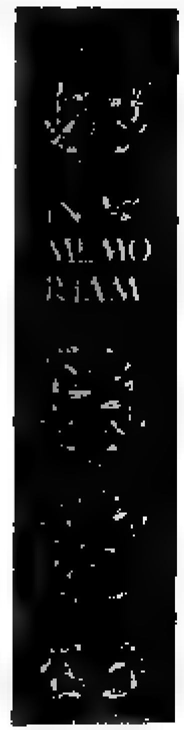


Fig 2.

Fig. 4.

Fig. 6.

Fig. 3.

Fig. 5.

point *b* $1\frac{3}{16}$ inches from the center. A semicircle whose radius is $1\frac{1}{4}$ inches will then pass through the point *c*. The center of the five-pointed-star form enclosed in the space between each of the figures *a b c* is 2 inches from the center, and is described within a circle whose radius is $\frac{3}{16}$ inch.

24. The alternate leaf forms on the intermediate lines between those just described consist of the right and left branchings of the stems that curl from the star form *d*, around under the principal figure, and back again toward their points of beginning. The upper points of these leaf forms *e*, Fig. 8, are $2\frac{1}{2}$ inches from the center of the plate, and branch $\frac{3}{16}$ inch each side of their center line, making their points $\frac{3}{8}$ inch apart. A semicircle whose radius is $1\frac{3}{8}$ inches marks the width of the rim of the plate, and two more semicircles whose radii are $\frac{5}{8}$ inch and $\frac{1}{2}$ inch, respectively, form the outlines of the simple device in the center of the plate.

25. In washing in this figure, the entire surface within the outlines must first be gone over with a No. 1 tint, and then the gore-shaped forms between the leaf forms *a b c* may be tinted evenly with a No. 6 tint. The entire background of the figure outside of the forms *a b c* and the central star form inside of the gore may now be laid over with a coat of distemper, or opaque color, about No. 12 in depth. The outline of this ground at the edge of the plate must first be sketched in, in pencil, observing that it follows in general contour the outline of the Arabian design. It is necessary that it be very carefully sketched, and the point over the ends *a* of the leaf forms, and the indentation between the points *e* of the foliated forms, be made to come exactly on the dividing lines.

When this has all been completed, the central portion of the leaf forms, and the star forms, may be laid in, in black, leaving the marginal line a trifle less than $\frac{1}{16}$ inch, as shown on the plate. After the design is completed, Chinese white may be used to touch up the lines wherever the color may

have run over slightly. In actual practice, all of the white part in this border would probably be executed in gold and the general background in a deep oriental blue. The gore shape between the leaf forms would possibly be a capucine or oriental red, and the circle in the center blue surrounded by a band of gilt.

This design adapts itself well for this class of work, inasmuch as it nicely emphasizes the structural detail of the plate commonly known as the rim and bears out the theory that was advanced in the consideration of the ornamentation of pottery in *Elements of Ornament*.

The student is advised to defer the brush work on these figures until the entire plate has been rendered in pencil, but the description of the tinting of each figure will be given with it, while the other details are fresh in the student's mind.

26. In Fig. 2 is shown a design of border decoration for a similar utensil but reduced to the lines of the Renaissance style wherein the ordinary thistle has been taken as the base of the decorative motive. In the arabesques of this style there is very little variety to the curves, no matter in what material they are executed. They are all derived from the original Roman idea of one curve growing out of another curve and ending in or encircling a flower. Exactly the same idea may be seen executed in ironwork, as illustrated in *Historic Ornament*, Part 3, with the exception that the latter illustrates practically the same design with a different vegetable form.

27. In drawing Fig. 2, the semicircle governing the outline of the plate is precisely the same as in the previous figure, and is divided by radial lines into four equal parts, as shown in Fig. 9. The general outline or parent stem of the decoration is then sketched in one of the subdivisions enclosed between the radial lines, as shown at *a*, and this is carried into the neighboring subdivision and across the bottom of it, as shown at *b*, and then repeats itself in the opposite

direction in the third subdivision shown at *c*. This guiding line also coils itself into a scroll in the subdivision *b*, but in the opposite direction from *a*, and simply consists of a general guiding stem running in a wavy line around the plate, throwing off a scroll on either side as it goes.

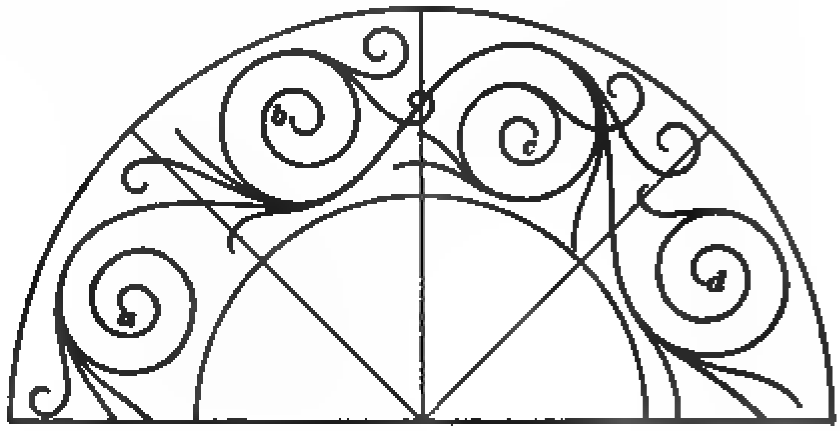


FIG. 9.

This stem is afterwards ornamented somewhat, by the application of the sharply serrated leaf form characteristic of the thistle, as shown in Fig. 10 (*a*), and the blossom of the thistle is conventionalized into a flat form, the original idea of which is drawn from Fig. 10 (*b*). The little starlike forms that are used for a powder effect on the background are taken from the thistle down and have for their original type, forms similar to Fig. 10 (*c*). In the center of the plate a number of flat conventional thistle leaves are superimposed, one over another, within a semicircle whose diameter is 1 inch. In both of these examples (Figs. 1 and 2) the ornament is suitable to its purpose and place and there is no tendency or feeling that it would be more suitable on some other object or that some other ornament would be more in place here. For instance, in Fig. 11 is shown a Moorish design applied to the general surface decoration of a plate, the design being similar in character to one shown in *Historic Ornament*, Part 2, where it is used as a wall decoration. Nothing could illustrate more forcibly the impropriety of a wall decoration for a plate decoration, for in Fig 11 (*a*) the ornament does not finish at the rim of the plate, and the very portions of the utensil that should be emphasized in order to acquire a

feeling of additional strength are weakened by the broken and uncertain ending of the design.

Fig. 10.

28. In Fig. 11 (*b*) the same design exactly is changed to suit the purpose of the utensil in which it is executed. The border around the rim of the plate is reduced to a series of links, not very elaborate in themselves, but suggestive of binding the rim of the plate together and certainly strengthening its form. In the center a rosette formed by the complicated geometrical work suits its place exactly and shows that it was intended for the place where we see it and not somewhere else.

29. Fig. 2 should be washed over with a No. 1 tint in the same manner as was Fig. 1, and then the general design

(a)

(b)

Fig. 11.

may be executed in a No. 6 tint and shaded with darker tones to give expression to the general idea. No distemper will be used in this, as the forms are much more freely rendered and are not composed of as many flat tints as in the previous case.

In both Fig. 1 and Fig. 2 a light tint may be laid so as to indicate the portion of the plate that rounds away from the border or rim, the depth of this being of little importance, as it is a shadow line and forms no element of the design itself, except in so far as it emphasizes the plate border and limits the area of decoration.

30. Fig. 3 is an example of a book cover in stamped leather, the style being that of about the middle of the sixteenth century. The original was olive-colored morocco, whereon the white outlines were executed in gold. The heavy black scrolls on each side of the center (medallion) were a deep purple, while the lighter scrolls of a similar outline were a light green. The background of the coat of arms on the oval was royal red, and the coat of arms, which is that of Katherine de Medici, was executed on the left with gold fleur-de-lis on a blue ground, and on the right with red and blue devices stamped on a gold ground. The back of the book was stamped with four golden K's, being the initial of Katherine, each one of which was crowned as shown.

31. To draw Fig. 3, construct first a rectangle $3\frac{3}{8}$ inches wide and $5\frac{3}{8}$ inches high, located $2\frac{3}{8}$ inches to the right and $4\frac{7}{8}$ inches below the border lines. This rectangle will represent the entire front or top of the book cover, but within it three other rectangles must be constructed $\frac{3}{32}$, $\frac{1}{4}$, and $\frac{9}{32}$ inch to the left of the right-hand side. The first of these rectangles will measure exactly 3 inches in width, and its upper and lower lines will be the same distance from the upper and lower lines of the enclosing rectangle, as on the right-hand side; the other rectangles within this will be parallel to it all around. The inner one will be divided as shown in Fig. 12, and from the location of the ornament as it crosses the lines

in Fig. 12, the student will be able to sketch in the design and then strengthen it up for his coloring.

The back of the book, shown to the left of the top view, is $\frac{11}{16}$ inch in thickness, and the ridges are $\frac{1}{4}$ inch in width

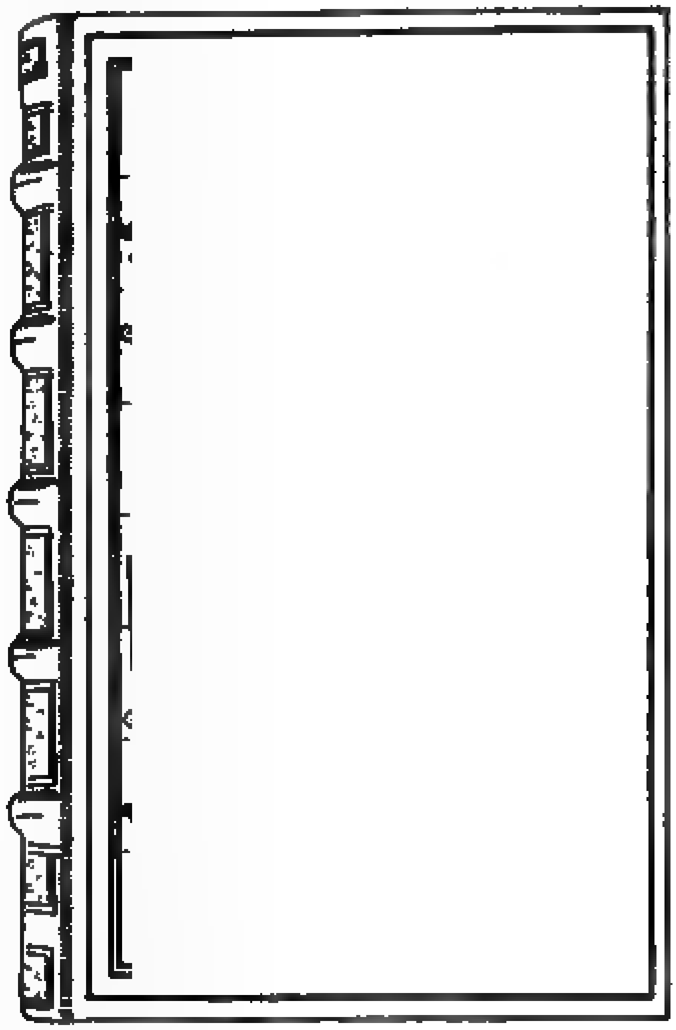


Fig. 12.

against the back but only $\frac{1}{16}$ inch at their extremities. The first one is located $\frac{3}{4}$ inch below the top, and the last one $\frac{3}{4}$ inch above the bottom; between these the others are spaced equally.

32. The student, after sketching in all his ornamentation carefully, will strengthen it with a hard pencil and then wash in the entire book cover to the depth of about tint No. 12. His pencil lines of ornament will show through this tint, and they can be gone over with a fine pen charged with Chinese white. The tinting of the scrollwork where it is lighter than the ground, and also the light portions of

the shield, can be executed in distemper, or Chinese white, charged with color. All of the straight-line work on this design should be executed with the ruling pen and Chinese white, care being taken that the white is sufficiently thick to leave a clear line.

33. Fig. 4 is another book-cover design of a modern style. It is also executed in stamped leather, but shows the conventional use of the daisy as a motive for ornament. This book cover measures $3\frac{1}{4}$ inches in width and $5\frac{5}{8}$ inches in length, and the panel, on the cover on which the design is executed, is $3\frac{1}{4}$ inches in width and about $\frac{1}{32}$ inch inside of the general outline. The back of the book is $\frac{15}{16}$ inch thick, and the six panels thereon are equally spaced and each $\frac{5}{8}$ inch square.

The daisies on the cover may be located by drawing horizontal lines $\frac{5}{8}$, $1\frac{3}{16}$, $1\frac{15}{16}$, and $2\frac{11}{16}$ inches below the top; the last measurement is to the center of the cover, and the spacings below the center are the same as those above. The lines just drawn will pass through the centers of the horizontal rows, and, by spacing the flowers so that the extreme outside ones are $2\frac{1}{2}$ inches apart, the centers for the circles, which are $\frac{1}{2}$ inch in diameter, contouring the outlines of these flowers, may be located. The lettering of the title is $\frac{1}{8}$ inch in height and may be drawn as shown.

34. The entire cover and back should be washed in to the depth of a No. 12 tint and the ornamentation worked thereon with Chinese white. It is no easy matter to handle Chinese white skilfully, and the student must not be discouraged if he does not succeed in doing perfect work the first time. In all of these drawing plates, it is the intention that the student shall experiment with his colors and his instruments long before he attempts to execute a plate that is to be sent in for criticism. Much design work is executed in white entirely, and the inability to use it as freely as black medium would handicap the practical designer in many branches of his profession.

35. Fig. 5 is an example of stamped-leather wall decoration from the Château de Blois, in France, and is the same decoration that was illustrated in Figs. 78 and 79, *Historic Ornament*, Part 3. Considerable liberty has been taken here with the coloring, in order to express in black-and-white the strong effect of the design itself. In the original, the entire background was a deep, olive green, and all the black portion, rich royal red. The white lines and surfaces, as in the previous examples, were executed in gold.

The rectangle bounding this design is 5 inches wide by $5\frac{7}{8}$ inches high, and is $\frac{3}{8}$ inch to the left of, and $\frac{5}{8}$ inch above, the border lines. To draw the design, the student will con-

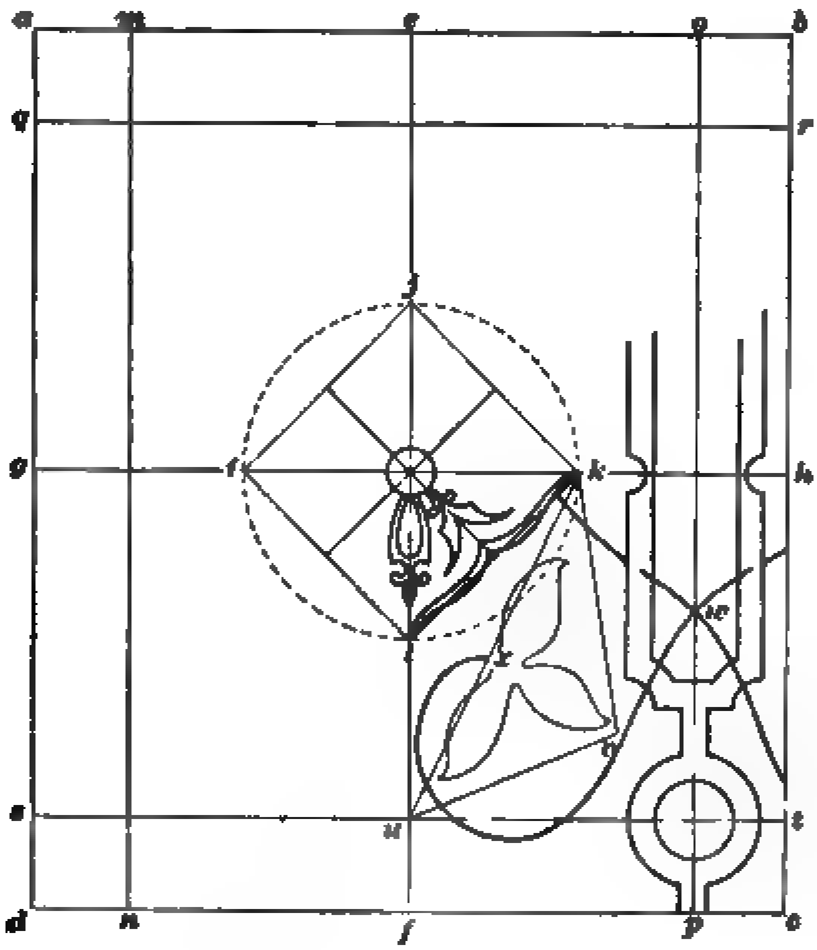


FIG. 13.

struct a rectangle as shown at *a b c d*, Fig. 13, and divide it through the center vertically and horizontally by the lines *e f* and *g h*. At the point of intersection of these central vertical and horizontal lines, a circle will be drawn the radius of which will be $1\frac{3}{16}$ inches, and within this circle is drawn

a square the angles of which will be on the vertical and horizontal dividing lines, as shown at *i j k l*. A distance $\frac{1}{8}$ inch within each of the bounding lines, vertical and horizontal lines may now be drawn as shown at *m n*, *o p*, *q r*, and *s t*, and their points of intersection will furnish the centers for the circles within which the royal initials *H* and *C* are to be drawn. The inner of these circles will have a radius of $\frac{1}{4}$ inch and will govern the width of the panels above and below them. The outer circles will each have a radius of $\frac{7}{16}$ inch, and the space between them will be filled in solid with waterproof black ink, as shown. These solid black circles govern the widths of the enclosing border to the panels between them and also the straight line connecting them with that panel border.

36. The leaf forms between the circles containing the initials and the central square are drawn within triangles as shown, the longer sides of which are formed by a line drawn from *k* to *u*, and the shorter sides measuring $1\frac{1}{2}$ inches from *u* to *v* and $1\frac{3}{4}$ inches from *k* to *v*. The point *x* where the stem crosses into this triangle is $1\frac{3}{8}$ inches from *k*. The other details may now be sketched in freehand. The leaf form may be outlined within the triangle as shown, and the stem sketched to pass gracefully from *x* and approach the line *e f*, without touching it, across the lower end of the triangle near *u* and extend below the line *s t* before it curves upwards to pass about the same distance from *v* that it did from *e f* but outside of the triangle. It crosses the center of the panel at *w*, and this is an important part, inasmuch as it must be so balanced that it will cross the stem from the neighboring panel at the same point.

These guiding lines are the same on all four sides of the central device, the only difference being that they reverse for the one immediately above and to the side of them. Take careful note of the crossings of these lines on *q r* and *s t* as well, and observe carefully the branchings of the peculiar conventional leaflets that spring out alternately on opposite sides.

37. When the figure is entirely outlined, it may be washed over entirely with a No. 1 tint and the general ground may then be laid in with distemper of a No. 6 tint, after which the black portions should be rendered in waterproof ink. It will be necessary in this figure to use Chinese white in carrying out the lines of the gold work, and the student should exercise great care to have his white mixed to a consistency that will permit it to dry a perfectly white line and at the same time flow nicely from the point of his smaller brush so as to be uniform in width, smooth in appearance, and graceful in its directions.

38. Fig. 6 is a stamped-leather wall decoration from the Château of Cheverny, in France, not far from the place from which the previous example was taken, but very different in its characteristics. The ground in this case was a deep red similar to that color in the previous example, but the figure was executed in blue and the contrast was very striking.

The rectangle within which this figure is drawn is the same size as in the previous case and is located similarly with reference to the neighboring border lines. It is divided vertically into five equal parts, as shown by the lines *a b*, *c d*, *e f*, and *g h*, Fig. 14. A horizontal line *i j* may be drawn $\frac{1}{2}$ inch below the top, and on this line $\frac{3}{8}$ inch each side of *a b*, two small circles may be drawn whose radii are $\frac{3}{32}$ inch and a trifle more than $\frac{5}{32}$ inch, respectively. A distance $1\frac{3}{4}$ inches below the top of the rectangle another horizontal line *k l*, may be drawn, and from points on this line $\frac{5}{16}$ inch each side of *a b*, arcs of circles should be drawn whose radii will be $\frac{3}{8}$ inch and $\frac{11}{16}$ inch, respectively, and vertical lines drawn through these centers as at *m n*. Then, with centers on the lines *m n*, with the same radius as the arcs *n o* were drawn, the arcs *o p* may be drawn until they intersect with the circles first described above. At a distance $2\frac{1}{2}$ inches below the top a horizontal line may now be drawn, and where this line intersects *a b*, draw a circle with a radius of $\frac{1}{4}$ inch, and on this line, $\frac{13}{32}$ inch each side of *a b*, locate the centers of two other circles whose radii are $\frac{3}{32}$ inch and a little over

$\frac{5}{32}$ inch, similar to the ones above. On a horizontal line located $3\frac{5}{8}$ inches below the top, centers must be located $\frac{1}{4}$ inch each side of *a b*, from which arcs should be drawn with a radius of $\frac{17}{32}$ inch until they intersect on the line *a b*; and additional arcs with a radius $\frac{1}{16}$ inch greater, drawn from these same centers to intersect on the same line *a b*. The horizontal line *q r* is located $4\frac{7}{8}$ inches below the top, and the

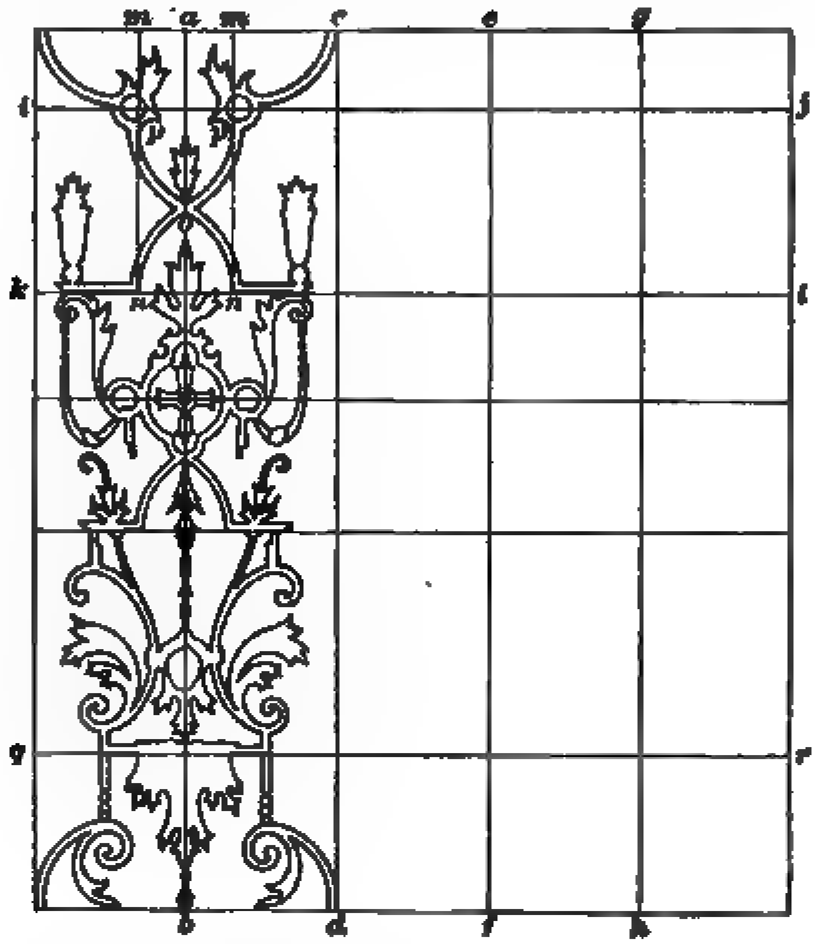


FIG. 14.

measurements from it and the other details already given should be sufficient to complete the outline of the figure.

It will be observed that this represents one complete repeat vertically and two and one-half repeats horizontally of the pattern. Therefore, the student will take great care that the termination of the devices at *d* and *h* will fit accurately on to the termination of the devices at *c* and *g*, as this will be their natural relative positions in the finished fabric.

39. When this figure has been entirely completed in pencil, it may be inked in with waterproof ink, using

LIGHT TE

Fig. 1.

EXTILES

Fig. 2.

instruments where necessary, and then after all pencil lines are erased, the entire surface may be washed over with an even No. 1 tint and the ground rendered in distemper to the depth of No. 6. The student will now ink in his border line, place the title at the top of the plate, his name and class letter and number in the lower right-hand corner and the date in the lower left-hand corner, as usual.

DRAWING PLATE, TITLE: LIGHT TEXTILES.

40. The two figures on this plate are taken from existing examples of French and Italian designs. Fig. 1 is a wall decoration the original of which was executed in stamped felt, the figure being left in relief and the background slightly sunken and forced to a smooth surface by means of hot iron dies. The design is characteristic of the Renaissance style and is suitable as a drop pattern for wall paper or any textile where a vertical figure is desirable.

41. In drawing Fig. 1, the rectangle containing it is $8\frac{5}{8}$ inches wide by $11\frac{1}{4}$ inches high, and it is placed $\frac{3}{4}$ inch to the right and above the border lines. Two center lines $a b$ and $c d$ should be drawn, each passing through the center of the unit of the pattern, as shown in Fig. 15. The design is a drop pattern falling one-half the length of a repeat in order to match from side to side; the scrolls enter the rectangle at e, thus forming a continuation of the scroll leaving the rectangle at f. In woven patterns, only one-half of this design would have to be worked out on design paper, the other half being duplicated by the center ties in the loom.

The entire figure should be worked out by the student as a problem in design, not as an effort to copy his drawing plate. He should now be familiar with the handling of conventional-leaf work similar to that which was applied to ornamental ironwork in one of the earlier plates of this course. The rendering of the various styles of foliage and ribbon is no different here from other pencil and brush work that the student has passed over, and with the vertical and

horizontal center lines as guides and the outline of the rectangle as the limit of surface covering, he should start in and scheme out a design based on the motives above set

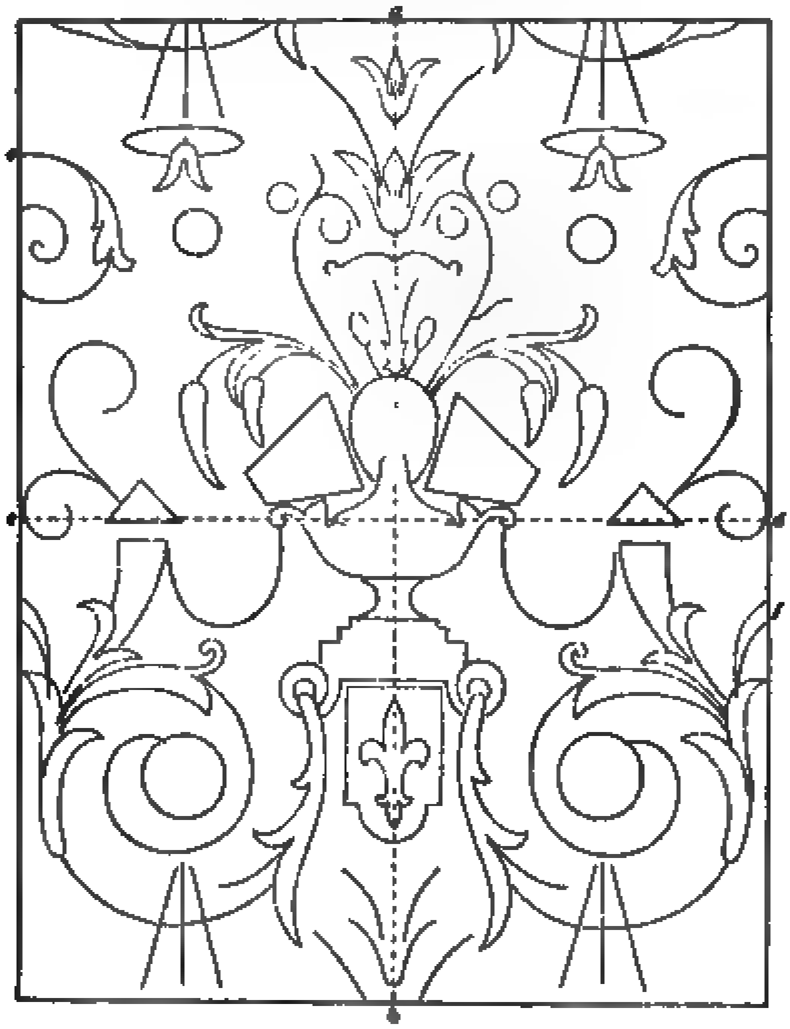


FIG. 15.

forth. This is not a problem in drawing but a problem in designing, and as such it will be considered and criticised.

42. The student must apply all the practical information he has received on his previous plates in the execution of the general outline of this work. Remember to keep a balance between the design and the background. Emphasize the lapping over of one part on another by means of fine white lines as was first done in the border on the Drawing Plate, title, Applied Design. When the whole design has been outlined satisfactorily, strengthen with a hard pencil the lines that are to become permanent, clean the plate with a soft rubber, and wash in the entire rectangle with a tint equal to No. 1

on the color chart prepared heretofore. The figure is then laid in with distemper or opaque color mixed so that it will dry to the depth of about No. 12. By this time the student should be able to go all over his work evenly and not be reduced in any place to the necessity of using Chinese white to touch up points of the background.

43. Fig. 2 of this drawing plate is an Italian silk design and its unit is a hexagon. The rectangle containing the design is the same height as the previous one, but is only $6\frac{3}{8}$ inches in width and is located $\frac{3}{8}$ inch to the left of the border line. The figures in this are extremely conventional but are all grouped around generally arranged lines that give them a feeling of unity in the general design.

For instance, in the center of each hexagon forming the repeat there is a single device surrounded by six radiating leaves and the whole enclosed in a foliated form nearly circular in shape. This really constitutes nearly all the material of one repeat.

44. To draw the figure, the student will construct within the rectangle one complete hexagon $5\frac{1}{2}$ inches in diameter, and interlocking with this other partial hexagons, as shown in Fig. 16. The governing lines of the composition may then be sketched in, using an ogee line instead of a hexagon as the center line, each side of which they will repeat. This ogee line must be of such a character that it will fit or interchange with itself quite as well as the hexagon; in order to do this, the corners of the hexagon may be rounded off, as shown at *a* in Fig. 16. The arc on which the roundings of these corners must be effected will have a radius equal to that of a circle described within the hexagon, and for the purpose of sketching the design, the hexagon may be abandoned entirely and the outline be carried out on the ogee as at *b*; but it should be borne in mind that it is the hexagon that forms the unit of this design although it is apparently ignored in the blocking out of the design. The background and surface coloring of Fig. 2 are precisely the same in tint

and handling as Fig. 1, and the student will finish the plate and put in the title, etc. without further instructions.

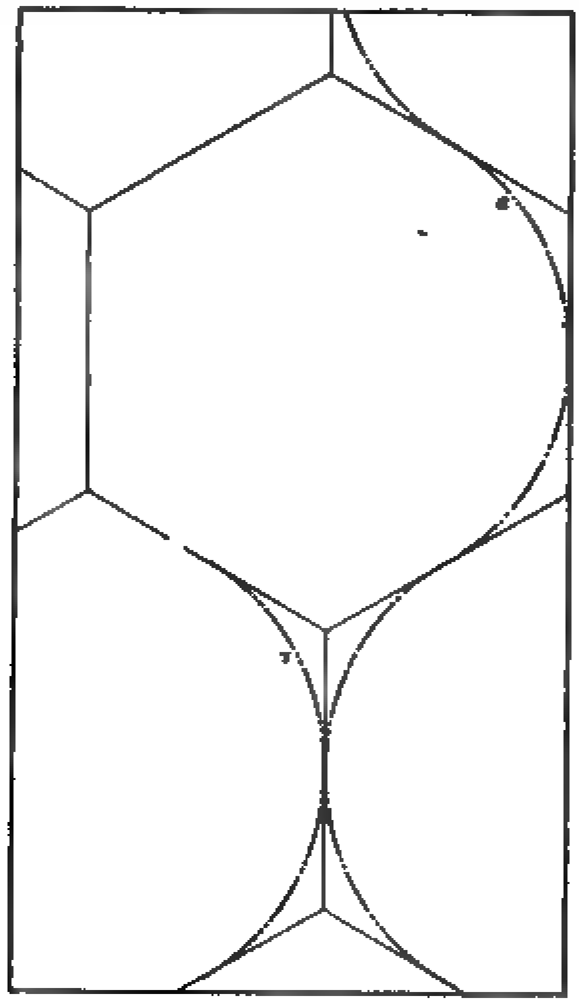


FIG. 16.

45. This will complete *Historic Ornamental Drawing*, Part 2, and the Drawing Plate, title, Light Textiles, is intended to act as an examination plate, testing the student's familiarity with what he has studied from the beginning of his course. The Drawing Plates, title, Linear Elements, and Surfaces and Solids, were only intended to test the student's dexterity after practice in linear work and eye measurement. The two plates in pencil that followed these introduced him to the application of simple geometrical elements to natural forms. Drawing Plates, title, Brush Work, and Applied Design, introduced him to a new method of expressing himself and the change that was necessary in the outlining and representing of objects in brush work. At that time he was supposed to know how to draw, and with the Drawing Plates, title, Historic Mural

Detail and Architectural Elements, we tested his ability to handle his pencil, pen, and brush, and at the same time taught him to use them in the first elements of design work. The Drawing Plates, title, Ceramics and Leather, and Textile Patterns, brought him still further in contact with the theory and practice of designing, and now with light textiles we expect him to put into practice all that he has learned, and he will find in the problems on this plate applications for all of the details that were introduced in each of the preceding plates.

This synopsis of the course up to this point is introduced here in order to remind the student that we are leading him to a point of independence, and if he does not find all that he thinks he requires in the instructions for this last plate, he is to look up his past suggestions in the directions for executing other plates, before he asks for further instruction.

ARCHITECTURAL DRAWING

INTRODUCTION

1. Architectural drawing includes both instrumental and freehand drawing, the latter being of the class known as ornamental drawing. The first constitutes the larger part of architectural drawing, and consists of straight and curved line work executed entirely with the instruments. The second is made up largely of curved-line work done freehand, although occasionally an irregular curve may be found useful.

In this section on *Architectural Drawing* the student will meet with architectural subjects that require no freehand drawing, except, in a few instances, to a limited extent. The drawing plates in this section are to be the same size as those in *Geometrical Drawing*, viz., 13 in. × 17 in. inside the border lines. No part is to be drawn nearer than ¾ inch to these lines, and no part of a drawing is to be inked in before the whole plate has been finished in pencil, as was explained in *Geometrical Drawing*. The student should show all the dimensions and dimension lines, also the shade lines and headings, when they occur, but he need not put in the letters of reference. Before proceeding with the drawing of the plates, we will first describe the use of the scales which are used to determine the relative proportions of the drawing.

SCALES

2. When a drawing is made to represent any object, so that the size of any part of that object may be measured from the drawing, the representation is said to be "drawn

to scale," no matter whether it is drawn full size of the original, or some definite fractional size. In order to make these drawings, an instrument called a "scale" is used to lay off the dimensions, so that they shall bear a uniform proportion to one another. To make a full-sized drawing, a scale, divided into inches and fractions of an inch, is used; but to make a half-sized drawing, a scale is used on which each 6 inches of its length is divided into twelve parts, each division being considered as 1 inch. In the same manner, a quarter scale has each 3 inches divided into twelve parts, and so on down to the scale of $\frac{1}{8}$ inch to a foot, where each $\frac{1}{8}$ inch of the scale represents 1 foot in length, and is divided into twelve parts to indicate the inches. This is the smallest scale ordinarily used in architectural work.

FIG. 1 Fig. 1 of the text shows a scale which is convenient for the student, since it combines eleven different systems of subdivision, and may be used to lay out all the work in this course in drawing. This scale is triangular in section and 12 inches in length, and on each of its edges is laid off a scale, as shown at *A*, *B*, and *G*. The scale at *G* is "full size"; that is, this edge of the scale is divided into inches and fractions of an inch, down to sixteenths, and is used for drawings that are the full size of the original. On the opposite side, at *B*, is shown the quarter-sized scale of 3 inches to 1 foot. The first 3-inch division, from *B* to *C*, is subdivided into twelve parts representing inches, and each inch is then divided into proportional fractions of an inch. From *C* to *D*, *D* to *E*, and *E* to *F* the scale is marked in its main divisions of 3 inches each. From *A* to *B* the scale is independently divided into spaces of $1\frac{1}{2}$ inches each,

to form an eighth-sized scale, or $1\frac{1}{2}$ inches to the foot, the divisions of the latter occurring on and between the marks for the 3-inch scale.

The other sides and edges of the instrument are divided into scales of 1 inch and $\frac{1}{2}$ inch, $\frac{3}{4}$ inch and $\frac{3}{8}$ inch, $\frac{1}{4}$ inch and $\frac{1}{8}$ inch, and $\frac{3}{16}$ inch and $\frac{3}{32}$ inch, respectively, making, with the full-sized scale at *G*, eleven in all. It will be observed that the numbering of the feet on these scales does not start at the end of the instrument, but at the first division from the end. As on the quarter-sized scale, the zero mark is placed at *C* and the first foot is measured to *D*. This is done so that the feet and inches may be laid off independently, and with one reading of the scale.

The figures indicating the number of feet on this scale are placed along the extreme upper edge at *D*, *E*, and *F*, to the right of the zero mark *C*; and those indicating inches, to the left of the zero mark. To lay off 2 feet $3\frac{3}{4}$ inches from a given point, place the scale on the point so that the 2-foot mark will be directly over it; then, from the zero mark *C* lay off $3\frac{3}{4}$ inches, as shown, locating a second point. The length of the distance thus laid off between the two points represents 2 feet $3\frac{3}{4}$ inches. The same remarks apply to the other scale of $1\frac{1}{2}$ inches to the foot, and the figures indicating feet on this scale are placed nearer the edge of the scale, in order to prevent confusion in reading.

To draw to a scale of half size, or 6 inches to the foot, use the full-sized scale, and remember that every $\frac{1}{2}$ inch equals 1 inch on the object; that is, that every dimension is only one-half the real length. To lay off $5\frac{7}{8}$ inches, first lay off 5 half inches and then $\frac{7}{16}$ inch over. The result is a distance of $5\frac{7}{8}$ inches to a scale of half size, or 6 inches to the foot.

In all kinds of architectural drawing, the smaller scales are used more frequently than the larger ones, and it is customary to speak of them as $\frac{1}{4}$ scale, $\frac{1}{8}$ scale, etc. when scales of $\frac{1}{4}$ inch or $\frac{1}{8}$ inch to the foot are meant. The student must therefore be careful not to confuse these expressions with the $\frac{1}{4}$ *size* and $\frac{1}{8}$ *size*, which refer to scales of 3 inches and $1\frac{1}{2}$ inches to the foot, respectively.

It sometimes happens that a draftsman is obliged to make a scale when the size of his drawing paper is limited and a general drawing of some object is desired. By **general drawing** is meant a complete view of the object in plan and one or two elevations. In such a case, one scale may be too large to enable a drawing to be made on a single sheet of the required size. Another scale may make it too small to show it up well. For example, where a $\frac{1}{4}$ scale may be too large, a $\frac{1}{8}$ scale may be too small, and a $\frac{1}{6}$ scale may be just right. If the draftsman has no $\frac{1}{6}$ scale (that is, a scale of 2 inches to the foot), he may make one by taking a piece of heavy drawing paper and cutting out a strip about the size of an ordinary scale and laying off the 2-inch divisions on it. Each division or part will represent 1 foot of the object. Divide one of the end divisions into twelve equal parts, and each will represent 1 inch of the object. Lines indicating half inches and quarter inches may be drawn, if considered necessary.

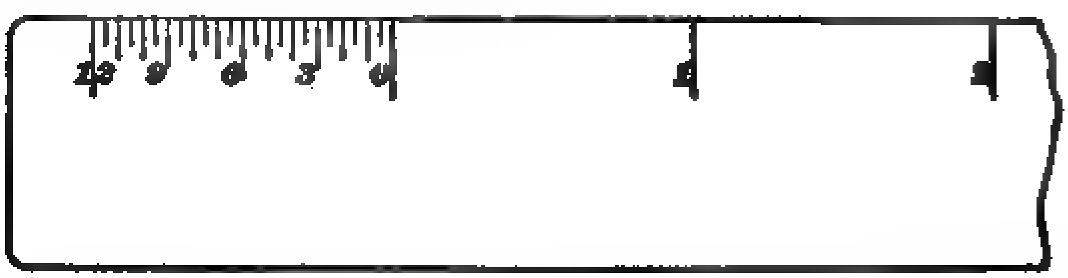


FIG. 2

In Fig. 2 of the text is shown part of a scale made in this manner, giving feet, inches, and half inches, the quarters, eighths, etc. of an inch being judged by the eye.

DRAWING PLATE, TITLE: MOLDINGS

3. This plate represents a series of architectural moldings, and demonstrates a method by which each may be geometrically drawn.

Fig. 1 shows a torus molding, which is half round, and here shown between two fillets.

Fig. 2 shows a cavetto, or cove, with fillets.

Fig. 2.

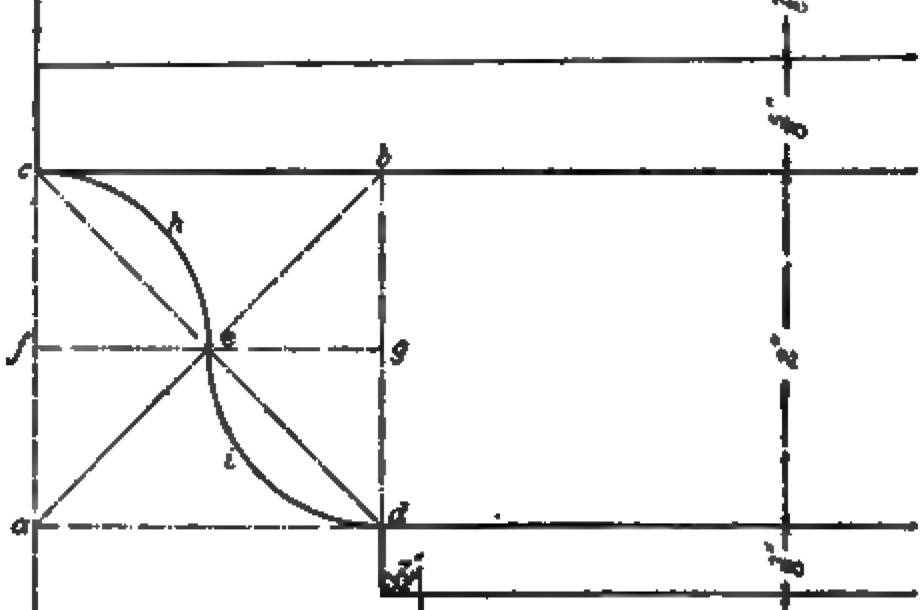


Fig. 3.

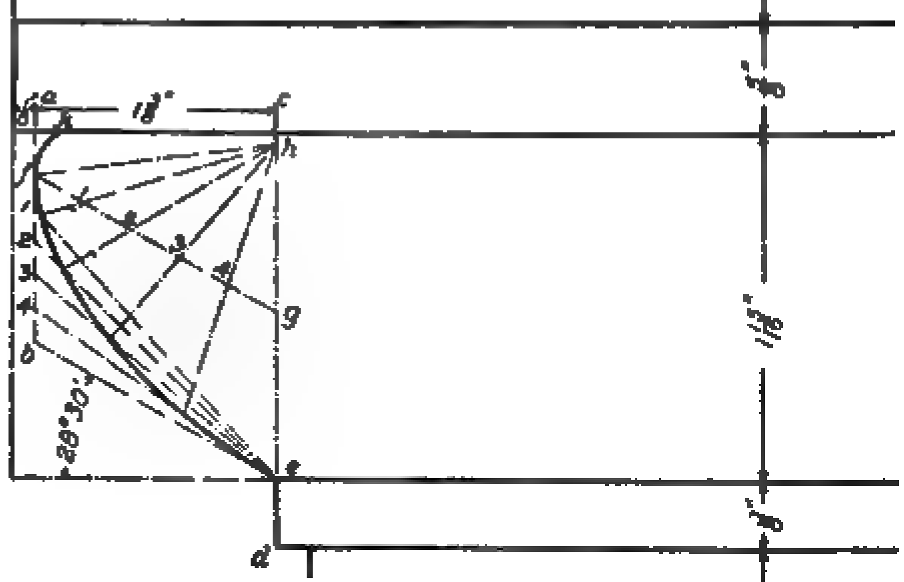


Fig. 4.

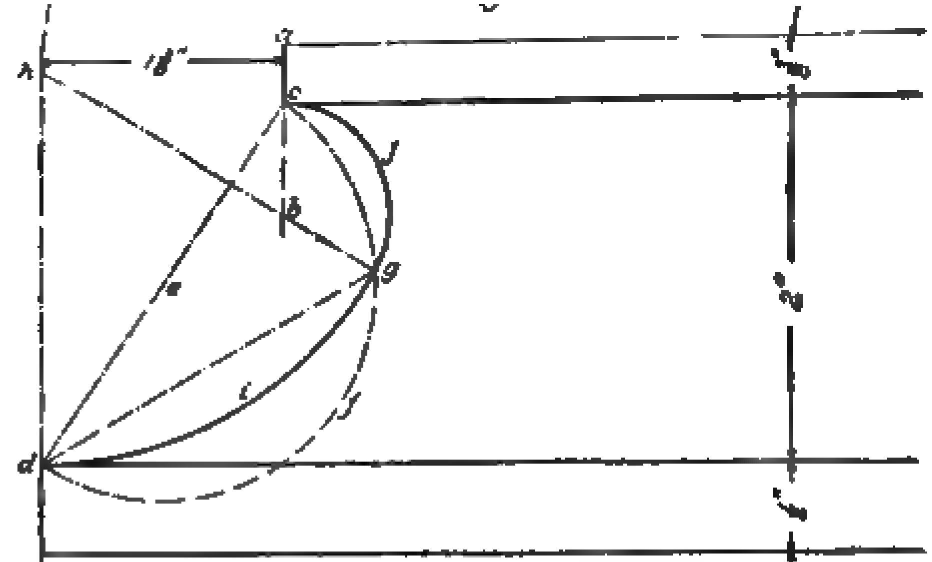


Fig. 7.

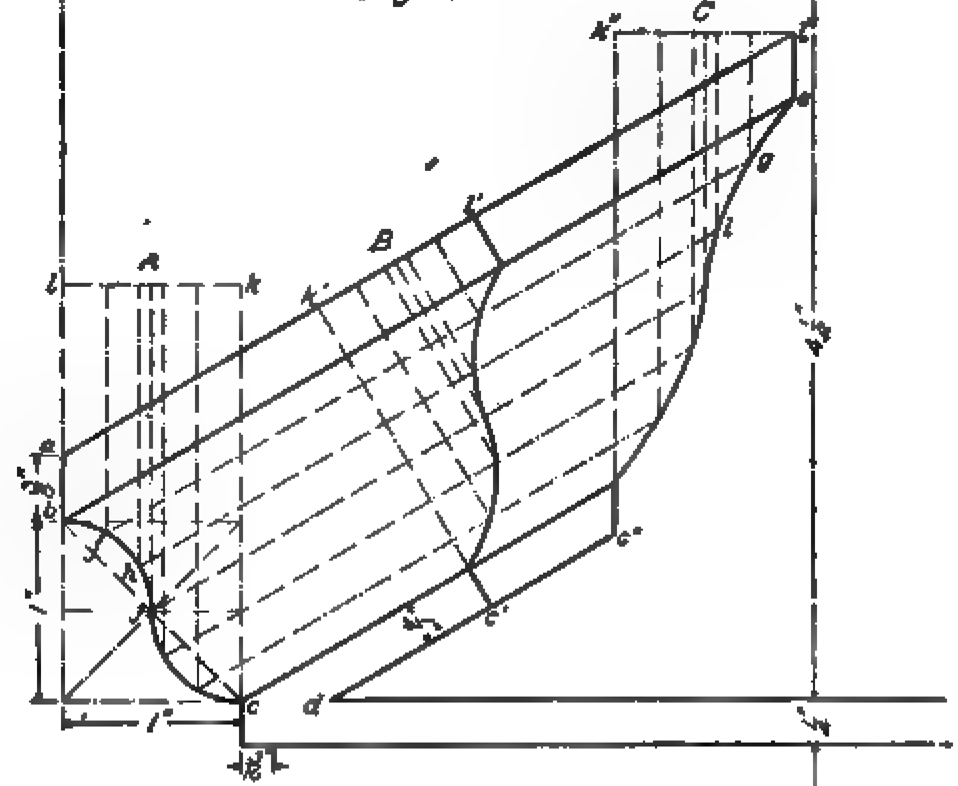


Fig. 8.

MOLDINGS.

Scale Full Size.

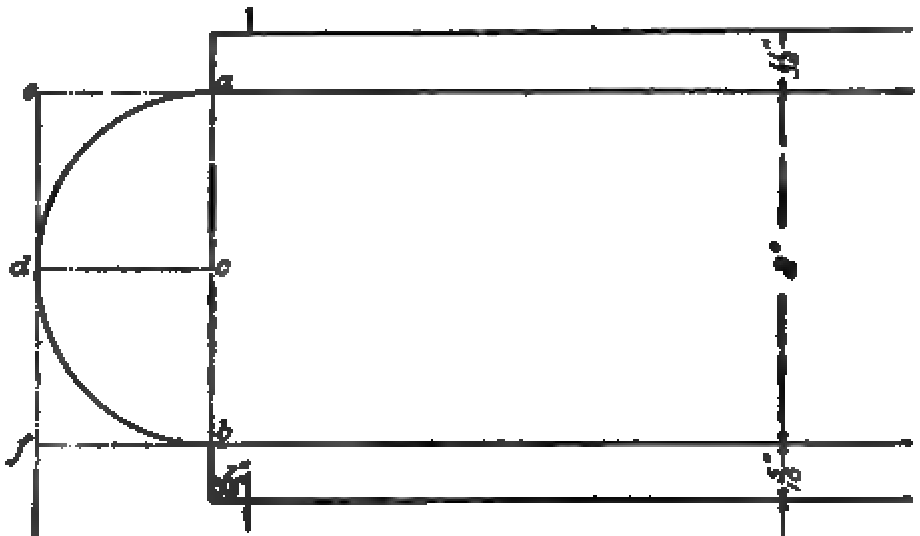


Fig. 1.

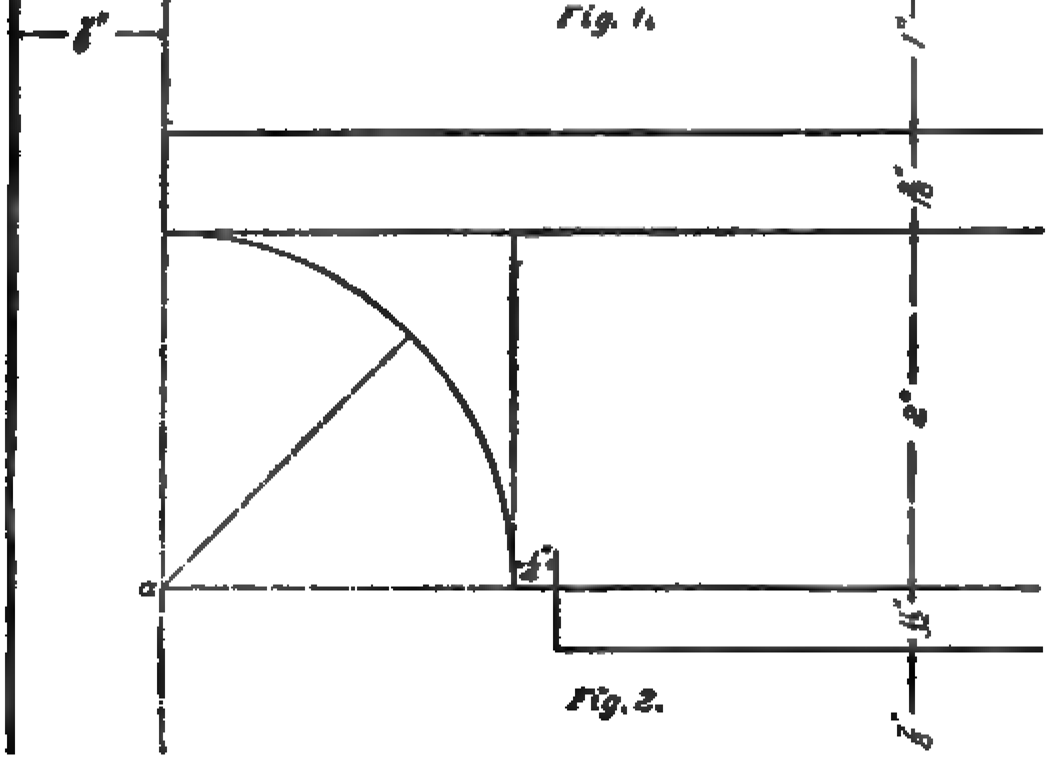


Fig. 2.

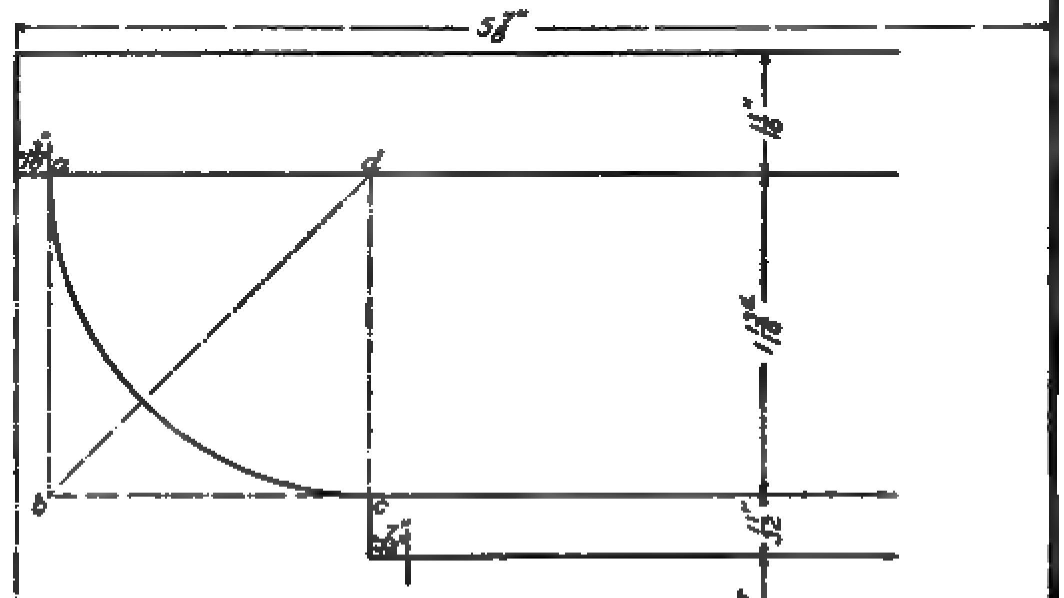


Fig. 3.

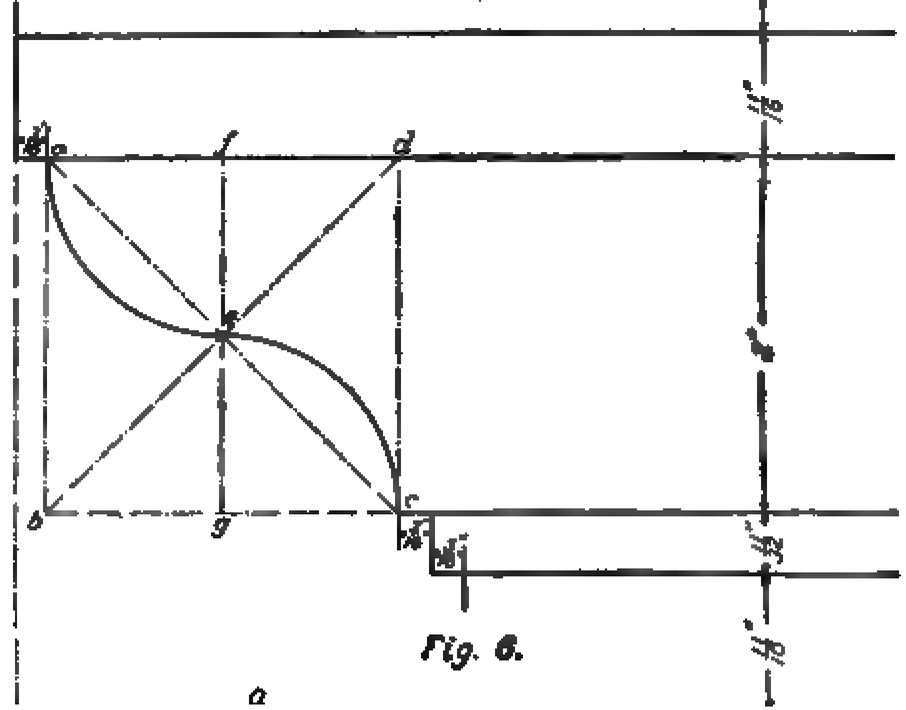


Fig. 6.

Fig. 3 shows a cyma recta, with fillets.

Fig. 4 shows an echinus, with fillets.

Fig. 5 shows a quarter round, sometimes termed an *ovolo*, with fillets.

Fig. 6 shows a cyma reversa, with fillets, which, with the cyma recta shown in Fig. 3, is usually called an *ogee*.

Fig. 7 shows a scotia, with fillets.

Fig. 8 shows the method of developing a raking crown molding of the cyma-recta type, with its accompanying fillets. The fillets are the narrow, square-edged pieces, above and below each molding, which are not included as a part of the molding itself, though they usually accompany it in order to clearly define the point where its curvature starts.

To draw this plate, mark off from the left-hand border line $\frac{7}{8}$ inch, and from the right-hand border line $5\frac{7}{8}$ inches, and through each of the points so located draw a vertical construction line full length of the plate. Then, from the lower border line, lay off the points that locate the horizontal lines of the fillets, and through these points draw the fillets, extending them to the vertical lines first drawn.

In Fig. 1, at a distance of $1\frac{7}{8}$ inches from the left-hand border line, draw the dotted line ab; bisect it at c, and from c as a center, with a radius ac, describe the semicircle adb, which is the convex outline of the member termed a *torus*. Then, from a and b, draw the short vertical lines that close the ends of the fillets.

A collar member, fulfilling a function similar to that of the torus, may be formed by a square-edged band instead of a half round, as indicated by the dotted lines ae, fb.

In Fig. 2, from the point a, which is the intersection of the upper line of the fillet with the vertical construction line, and with a radius equal to the width of the cove, describe a quarter circle intersecting the vertical and horizontal lines limiting the member. This concave outline is the profile of the molding technically termed the *cavetto*, though often called a *cove*.

In Fig. 3, locate the points a and c at the intersection of

the vertical construction line and the horizontal lines limiting the curved member. From *a* and *c*, by means of a 45° triangle, draw the diagonal lines *a b* and *c d*; these lines will intersect at *e*, and will be the point of the reverse of curvature. Through *e* draw the horizontal line *f g*. From the point *f*, with a radius equal to *f c*, draw the arc *c h e*; and from *g*, which is located on the vertical line *b d*, with the same radius, describe the arc *e i d*; then draw the vertical fillet lines from *c d*, completing the outline of the figure.

In Fig. 4, draw the vertical line *a b*, limiting the projection of the echinus $\frac{1}{8}$ inch from the vertical construction line. Draw the vertical line *c d*, at a distance of $1\frac{3}{8}$ inches from *a b*. Draw the tangent *b e*, by means of the protractor, at an inclination of 28° 30′ from the horizontal line. From the point *f*, which is $\frac{1}{4}$ inch below the lower edge of the upper fillet, draw the line *f g* parallel to *b e*. From *g* lay off *g h* equal to *g e*. Divide the line *f g* into five equal parts, and mark the points of division, as *1*, *2*, *3*, etc., on *f g*. Divide *f b* into five equal parts, and mark the points of division, as *1*, *2*, *3*, etc. on *f b*. From *e* draw a series of lines to the points of division on *f b*, and from *h* draw a series of lines through the points of division on *f g*. The intersection of the lines *e 1*, *e 2*, *e 3*, etc. with the prolongation of the lines *h 1*, *h 2*, *h 3*, etc. will give points through which the lower portion of the curve may be drawn from *e* to *f*, either freehand or with an irregular curve.

The convexity of the echinus will depend on the inclination of the tangent *b e*, for, as the angle is increased, the curve will be flattened. The upper portion of the curve from *f* to *k* is drawn freehand, after locating *k* $\frac{1}{8}$ inch to the right at *a b*. The ends of the fillets are then finished as above.

In Fig. 5, draw the vertical line *a b* $\frac{3}{16}$ inch to the right of the vertical construction line limiting the projection of the moldings, and from the point *b*, at the intersection of this line and the horizontal line *b c*, draw the diagonal line *b d* at an angle of 45°. From the point *d*, with a radius *d c*, describe

an arc, which will be the convex outline of the molding: then draw the ends of the fillets.

In Fig. 6, draw $a\,b$ as above described, and from the point b, at the intersection of the vertical and horizontal lines $a\,b$ and $b\,c$, draw a diagonal line at an angle of 45°. From a draw a similar line intersecting with the lower line of the molding at c. The line $a\,c$ will intersect with the line $a\,b$ in e. Through e draw the line $f\,g$, at right angles to $b\,c$. From the point f, with a radius equal to $f\,e$, describe the arc $e\,a$, and from the point g, with the same radius, describe the arc $e\,c$, thus obtaining the contour of the reversed curve, or ogee; then draw the ends of the fillets.

In Fig. 7, draw the line $a\,b$ at a distance of $1\frac{3}{8}$ inches from, and parallel to, the vertical line limiting the projection of the lower fillet. Join c and d; bisect $c\,d$ at e. From e, with a radius equal to $e\,c$, describe the arc $c\,f\,d$. From d draw the line $d\,g$, at an inclination of 30° from the horizontal. On $d\,g$ as a base, erect an equilateral triangle $d\,h\,g$; from the vertex h, with a radius equal to $h\,g$, describe the arc $d\,i\,g$, which will be the lower curvature of the scotia. From the point b, at the intersection of the vertical line $a\,b$ with the line $h\,g$, and with a radius equal to $b\,c$, describe the arc $c\,j\,g$, which will be the curve of the upper portion of the molding.

In Fig. 8 is shown a cyma recta, similar to that in Fig. 3, except that its lines are carried up in a slanting direction, as would be the case if it were applied to the gable, or pediment, of a building. At A, B, and C are shown three profiles of the molding, which are necessary to properly miter the pieces together at the angles formed at the eaves and return.

Draw the normal molding $b\,j\,c$ by the method given for Fig. 3, but carry the lines of the upper fillet up from a and b at an angle of 30°. The lower fillet is then drawn horizontally and split at the end, to make it also extend diagonally and parallel to the upper fillet $a\,b''$. To find the contour of the molding which may be applied to the rake of the gable, or pediment, and to make it miter properly with $b\,j\,c$, divide the normal contour into six equal parts at $f\,h\,j$, etc., and from these points of division erect perpendicular lines until they

intersect with the horizontal line *l k* drawn 1 inch above *a*. Also draw lines from *f*, *h*, *j* parallel to the raking lines of the pediment, as *f g*, *h i*, etc. Now, from *k'*, 1⅛ inches from *a*, lay off *k' l'* equal to *k l*, and divide *k' l'* into the same number and sized parts as *k l*. This may be done by marking these divisions on a strip of paper and transferring them to *k' l'*. From these points of division, draw perpendiculars to *k' l'*, and, where these perpendiculars intersect the lines drawn from *f*, *h*, *j*, etc. parallel to the rake of the molding, points are determined through which the profile *l' c'* may be drawn.

The return profile, which occurs near the top of an open pediment, may be found in a similar manner, as shown at *C*. Here *k'' l''* is laid off horizontally and divided in exactly the same proportion as *k l*, and from these points of division perpendiculars are let fall to intersect with *f g*, *h i*, etc. as before, thereby locating points through which the molding may be contoured from *l''* to *c''*.

Having drawn all the figures in pencil, the student is now ready to ink in. As before stated, he should ink in each figure separately and finish it before commencing to ink the next figure, and it is well to ink them in the same order they were drawn in pencil. In inking in each figure, all the curves of that figure should be inked first, then the horizontal lines, then the perpendicular lines, and then the oblique lines. When the figures have been inked, the drawing should be cleaned, and after this the dimensions and dimension lines and the scale of each figure should be put in; also, if any part of the figure is shown in section, as will be the case with future plates, the part sectioned should be put in last. By putting in the sectional lines last, the likelihood of running them through the dimensions is greatly lessened. After this the border line should be inked in, and then the title, name of the student, his class number, and the date when he finished the drawing.

4. Sectional views of objects are represented in two ways: *first*, by coloring, and, *second*, by means of section

lines. When they are colored, different tints are used to represent different materials, so that, when a surface is to be tinted in which two or more different materials appear, one may be distinguished from another by its color. No general rule is strictly adhered to among architects by which certain tints will always represent certain materials. Each draftsman uses the color that suits his fancy. The general tendency, however, among all is to make brickwork of a reddish tint, stonework of a grayish tint, and woodwork of a yellowish tint, and so on, generally using a tint of about the color of the object. In this course of drawing none of the plates will be tinted, but sectional lines will be used exclusively. The same difficulty presents itself here as in the case with the tinting, that no standard is observed among architects, but each uses that style which he thinks best. It is impossible to have a separate style of section for each material, and therefore one style of sectioning may represent half a dozen different materials. The section lines ordinarily used will appear on the various plates to be drawn from this subject, and will be explained as they occur.

5. The alphabet shown in Fig. 3 below is the antique Egyptian style of letter, and is to be used for titles and headings. The letters and figures are to be made $\frac{5}{16}$ inch high and $\frac{5}{32}$ inch wide, exclusive of tips at top and bottom,

FIG. 3

except *M*, which is $\frac{1}{4}$ inch wide, and *W*, which is $\frac{5}{16}$ inch wide. The thickness of the lines forming the letters is $\frac{1}{32}$ inch. The distance between any two letters of a word is $\frac{1}{16}$ inch between the tips, except where *A* follows *P* or *F*;

where *V*, *W*, or *Y* follows *L*; where *J* follows *F*, *P*, *T*, *V*, or *W*; where *T* and *A* are adjacent, or where *A* and *V*, *W*, or *Y* are adjacent; in these cases, the lower extremity of *A* and the upper extremity of *P*, *T*, *V*, or *W* are in the same vertical line.

Since these letters are composed almost entirely of straight lines, they can be made with the T square and triangle, the corners being rounded freehand. The width of the letters *L* and *E* should be a trifle less than $\frac{5}{32}$ inch, say about $\frac{1}{8}$ inch, in order to equalize the appearance of the spacing. The tops and bottoms of the rounded letters should be drawn with a radius equal to $\frac{1}{2}$ the width of the letter, and should each extend a trifle above the line governing the general height, or they will appear too short. Horizontal spaces between the rounded letters should, for similar reasons, be a trifle less than between the straight letters. In making the title of the drawing plates, the student should draw six horizontal lines in lead pencil to represent the thickness of the letters at the top, center, and bottom; then, with the triangle, he should draw in the width of the letters and the spaces between them in pencil. Having the letters all laid out, he can very easily ink them in. When inking them in, it is well to ink in all the perpendicular lines first, next the horizontal lines, then the oblique lines, and the tips, the latter being drawn with a 45° triangle.

DRAWING PLATE, TITLE: DESCRIPTION OF ARCHES

6. The printed plate entitled, Description of Arches was obtained by making the drawing to the scale $\frac{3}{8}$ inch = 1 foot, and then reducing it slightly by photolithography. Consequently, the divisions on the scale shown on the plate are not quite $\frac{3}{8}$ inch, but as the figures are reduced in the same proportion, their dimensions may be obtained by measuring with the reduced scale on the plate. Assume that it is desirable to obtain the span of the

DESCRIPTION[illegible]

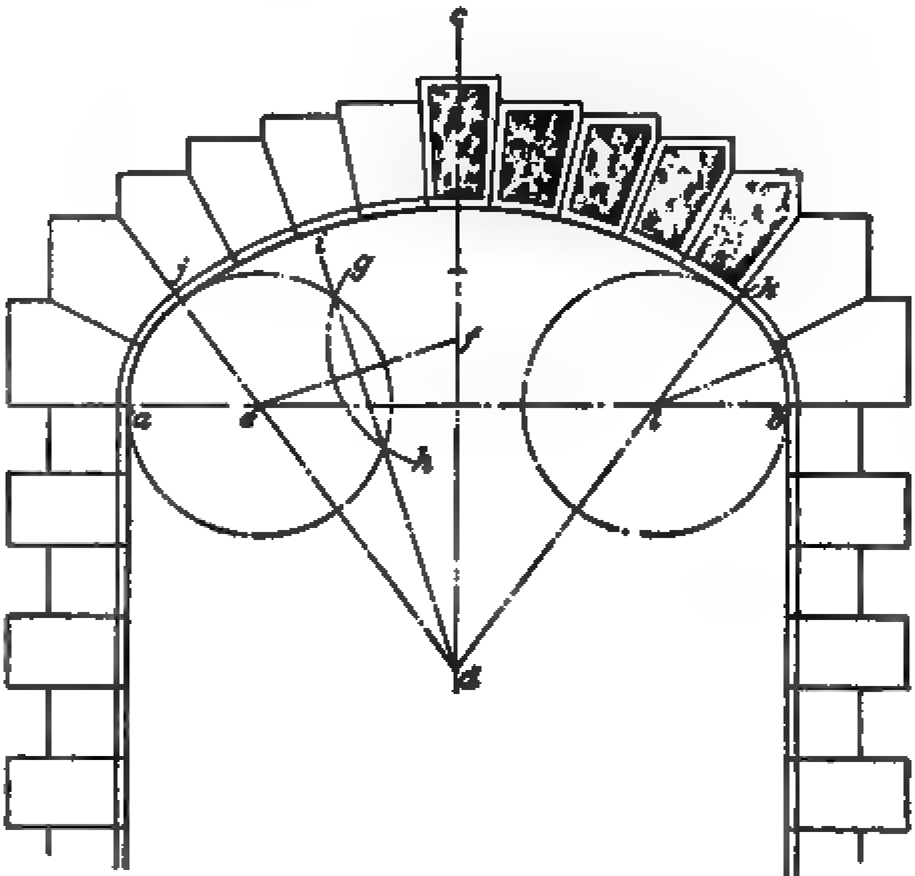


Fig. 1.

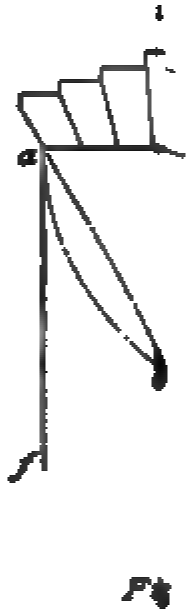


Fig.

Scale

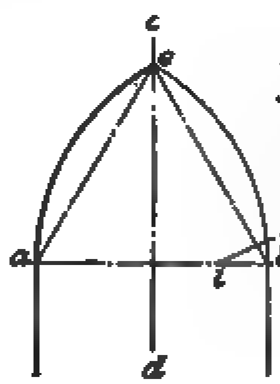


Fig. 5.

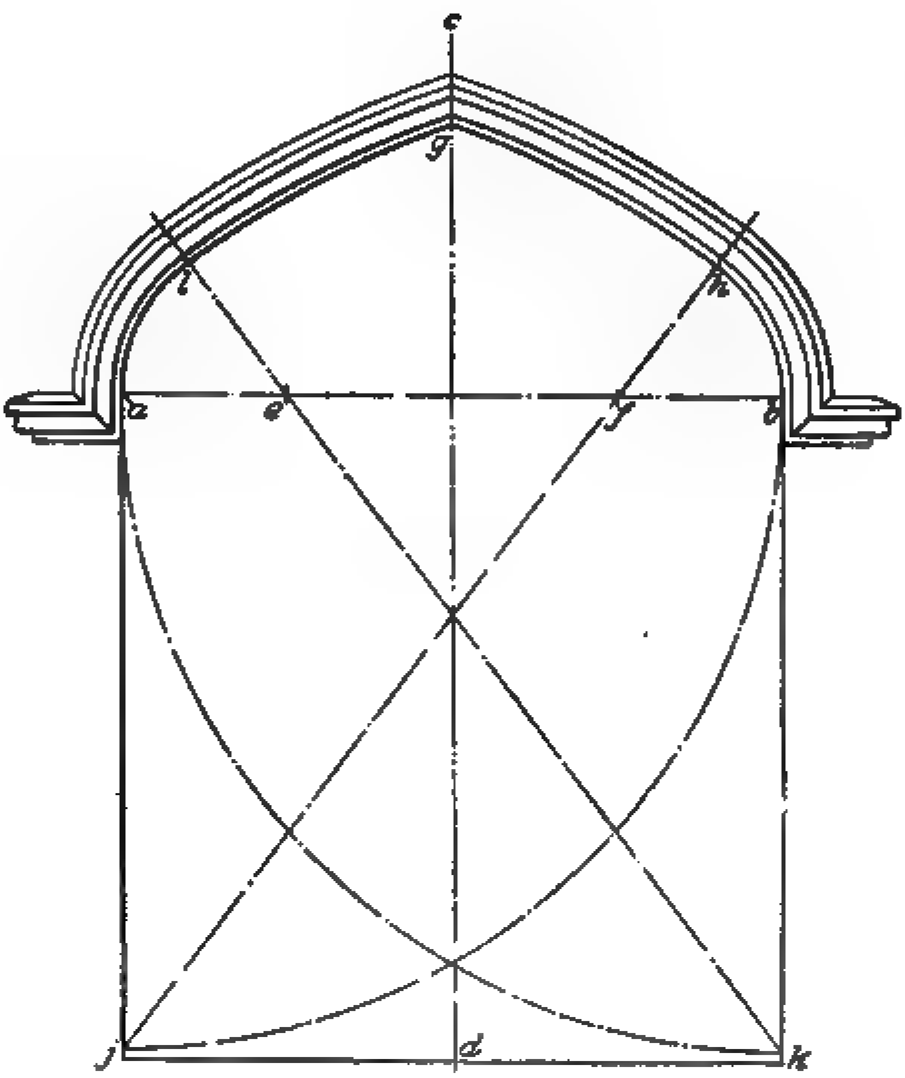


Fig. 4.

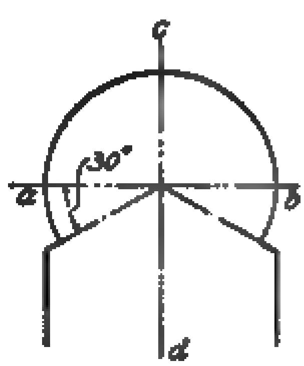
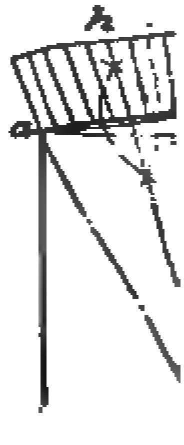
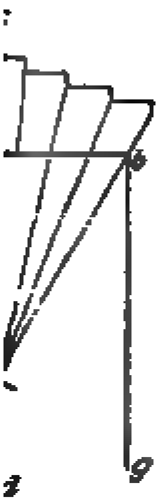


Fig. 8.



OF ARCHES.



2.

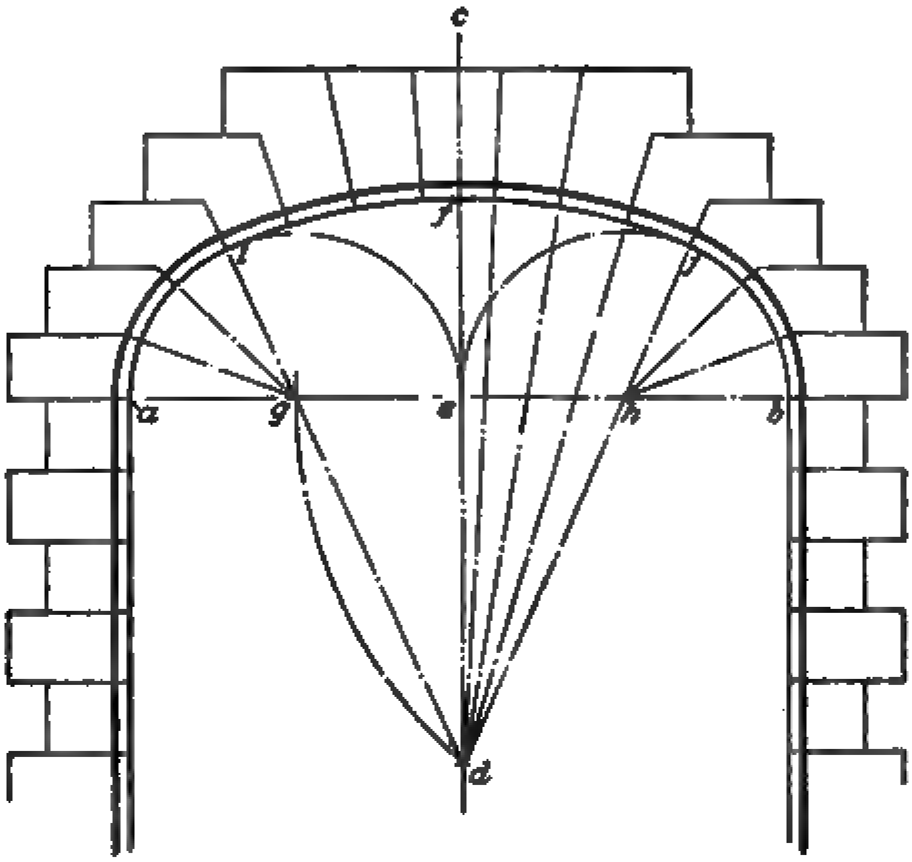
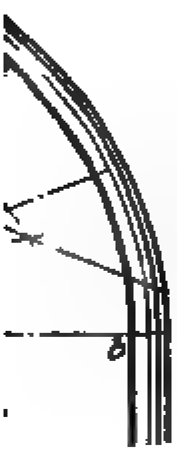


Fig. 3.



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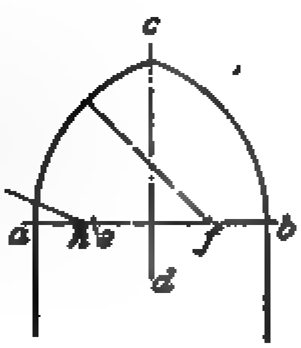


Fig. 7.

9.

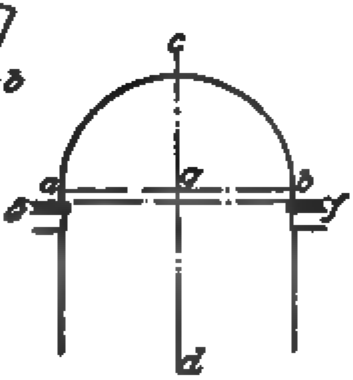


Fig. 10.

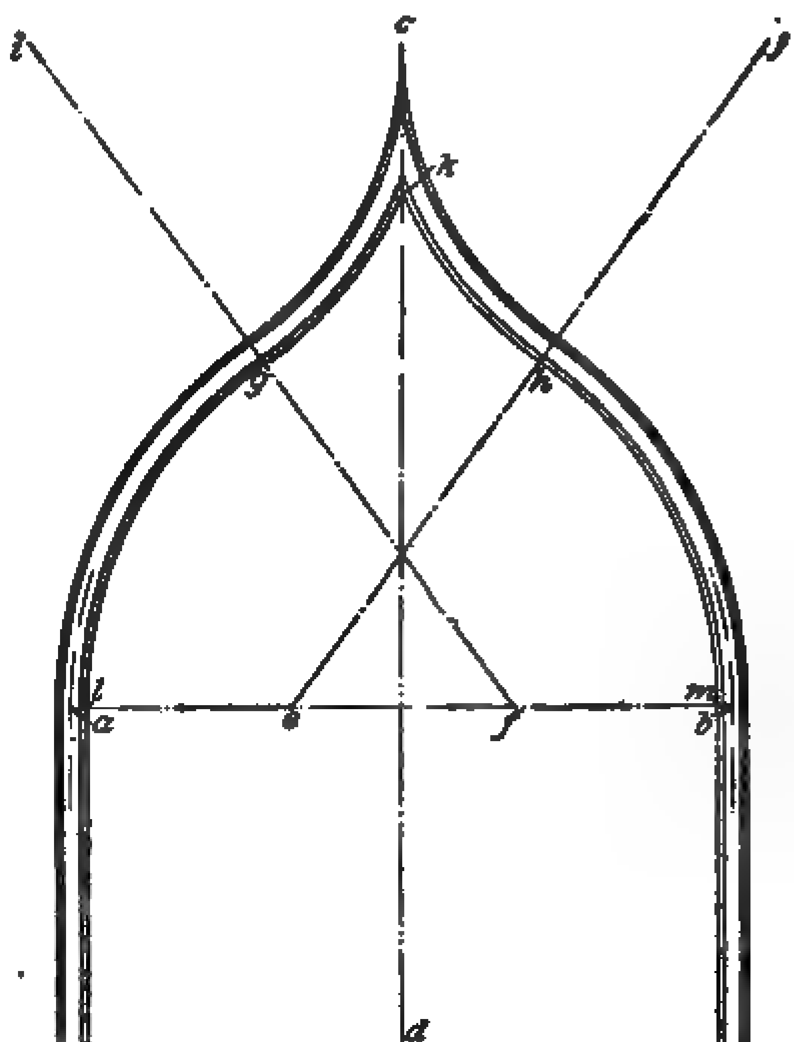


Fig. 11.

DESCRIPTION

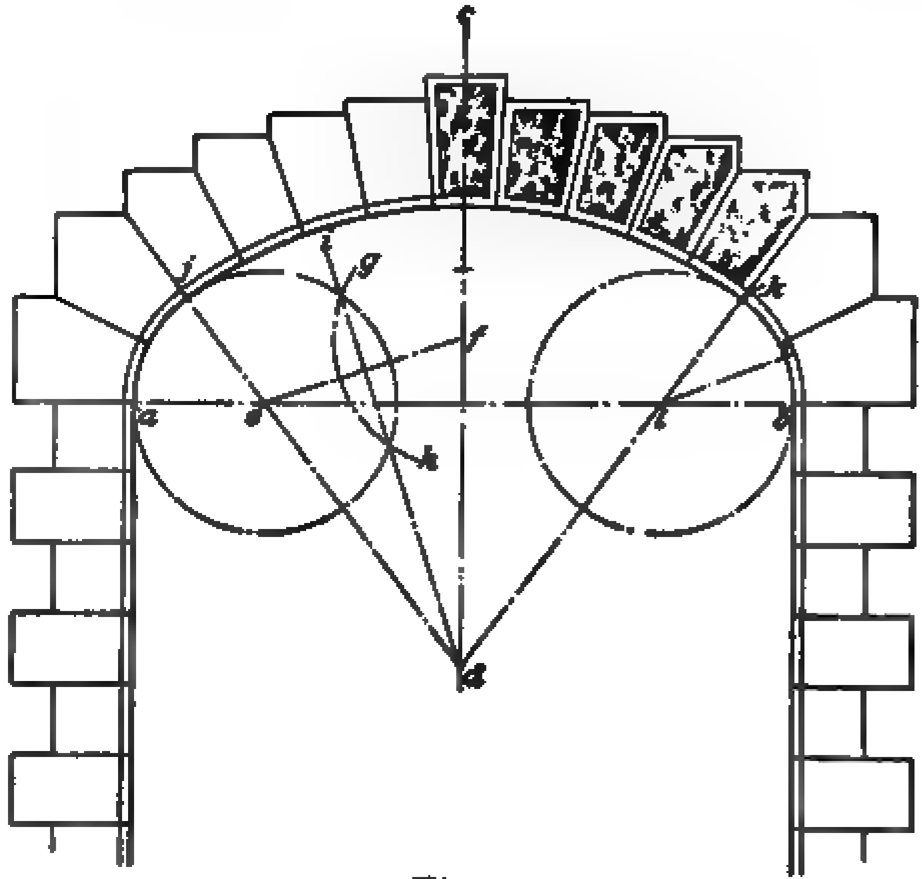
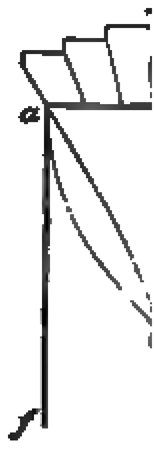


Fig.1.



Fi

Scale

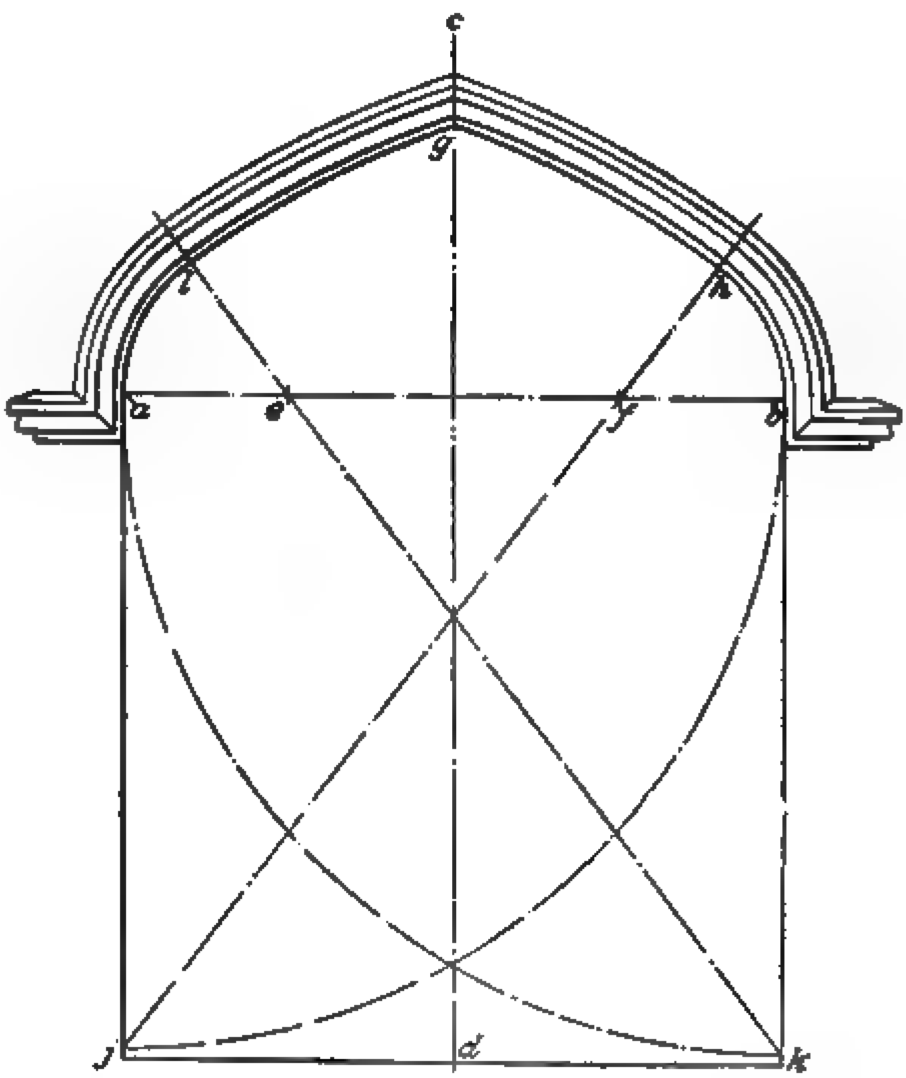


Fig.4.

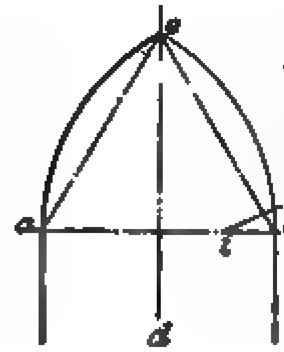


Fig.5.

F

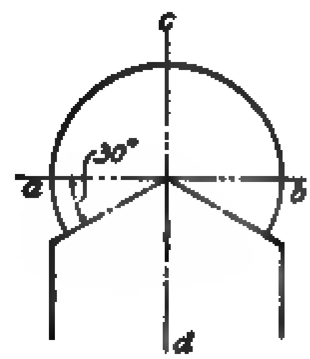
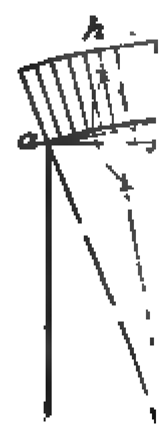
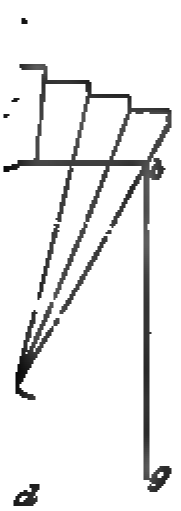


Fig.8.



F

... OF ARCHES.



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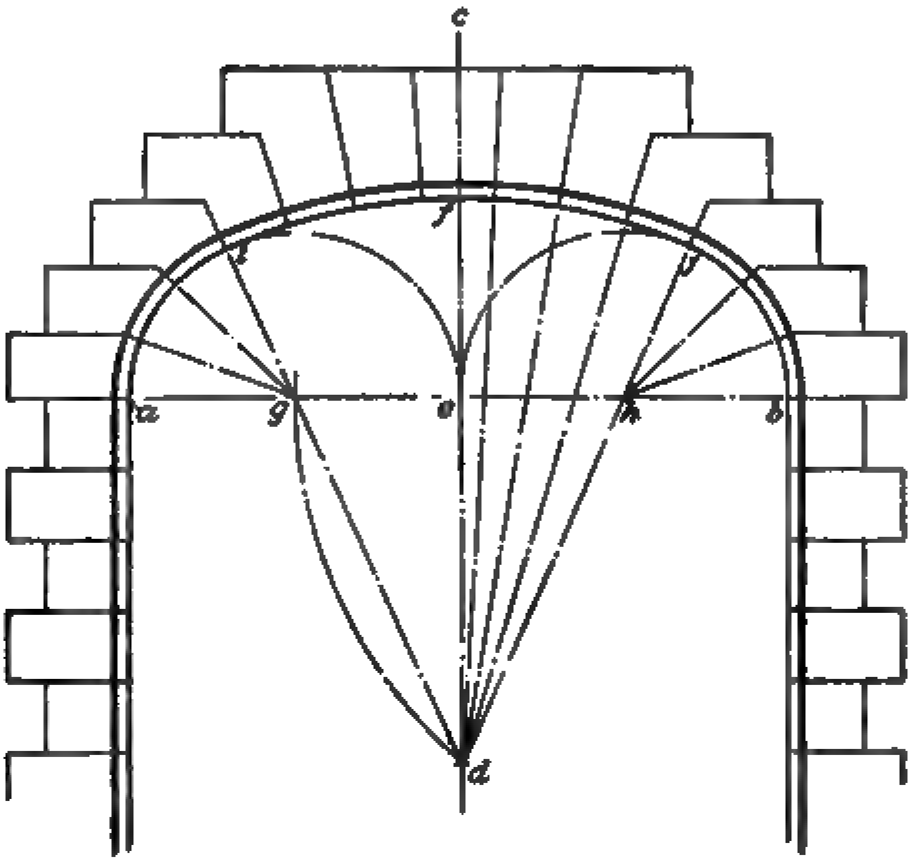
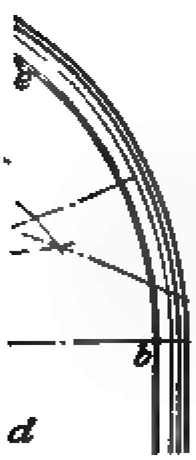


Fig. 3.



...g 6.

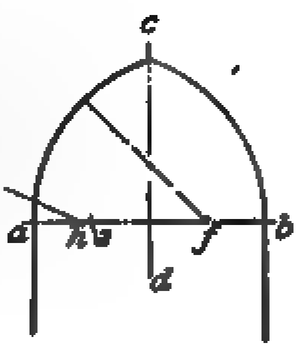
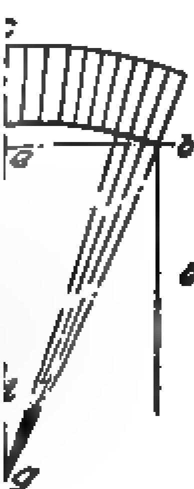


Fig. 7.



...g. 9.

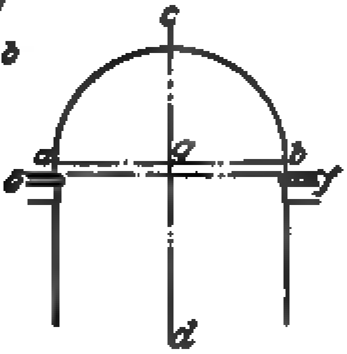


Fig. 10.

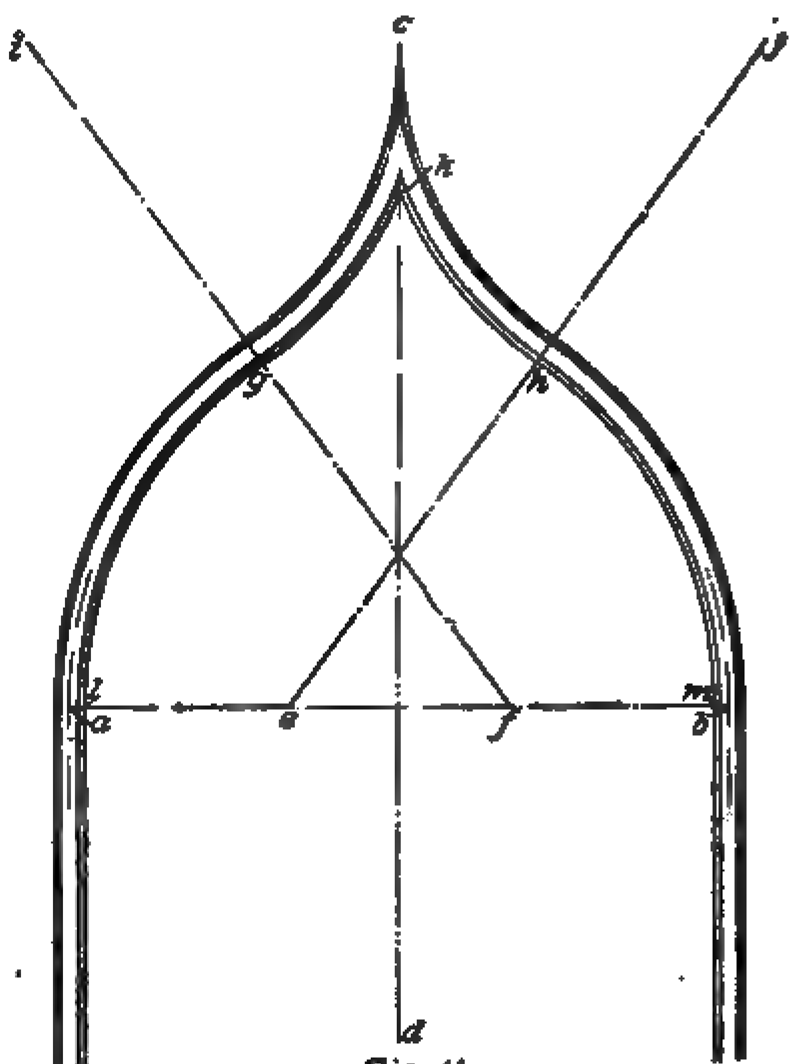


Fig. 11.

...United States.
...ERY ENGINEER COMPANY.
...ers' Hall, London.

arch in Fig. 1. By setting the dividers to the points *a* and *b* and transferring them to the scale on the plate without changing their position, *a b* is found equal to 10 feet. Then, on the student's drawing, this distance just found is laid off to the scale $\frac{3}{8}$ inch = 1 foot, thus making *a b* equal to $3\frac{3}{4}$ inches. In the same manner the dimensions of any line may be found by setting the dividers to the distance on the printed plate and applying them to the scale, which shows the length in feet and inches.

The diagrams on the plate are given to demonstrate geometrical methods of laying out the several kinds of arches commonly used in building construction. Figs. 1 and 3 are known as *three-centered* arches, from the fact that their profiles correspond to the arcs of circles struck from three centers. Fig. 2 is commonly designated as a *flat* arch. This arch is built of wedge-shaped stones, which serve as a lintel. These stones are so formed as to produce a pleasing appearance, and form a treatment that is much used in some styles of architecture. Fig. 4 is commonly called a *four-centered Gothic* arch, sometimes known as a *Tudor* arch. Figs. 5, 6, and 7 are known specifically as *equilateral*, *lancet*, and *low*, respectively, while Fig. 11 represents an *ogee* arch. Figs. 8, 9, and 10 are formed from single arcs of a circle, and are designated as *Moorish*, or *horseshoe*, *segmental*, and *stilted semicircular* arches, respectively.

To proceed with the drawing of the plate, commence by laying out Fig 1. Draw the center line *a b* $2\frac{27}{32}$ inches from the upper border line, and the center line *c d* $3\frac{3}{16}$ inches from the left border line. Lay off the span and the rise to scale, which throughout the plate is $\frac{3}{8}$ inch = 1 foot. Divide the rise into three equal parts, and divide the span into five equal parts, thus locating the points *e* and *l*. Connect *e* and *f*, and, with a radius equal to *e a*, describe the circles designated. With *f* as a center and the same radius, describe the arc *g h*, and through the points where it intersects the circle, draw the line *d i*. Where this line intersects the vertical center line *c d*, will be the center for the arc of the circle forming the crown of the arch. This arc will continue from

the point *j* on the left to the point *k* on the right, at which points it will be tangent to the circles previously drawn. Draw the radial lines representing the joints between the voussoirs to the centers as designated, and finish the figure by drawing in the stones as shown. The term *voussoir* is French, and is given to the wedge-shaped stones that form the arch.

Commence Fig. 2 by drawing the vertical center line *c d* exactly through the center of the clear space between the border lines, or at a distance of $8\frac{1}{2}$ inches from either of the side border lines. The line *a b* is located $2\frac{7}{8}$ inches from the top border line. Draw the outline of the window opening *a b f g* to scale, and with *b* as a center, and a radius *a b*, describe the arc *a e*. Where it intersects the center line *c d*, locate the point *e*, and draw *e a* and *e b*. Divide *a b* into seven equal parts, and from the point *e*, through these points of division, draw radial lines representing the lines between the voussoirs. Finish the outline of the voussoirs to scale, completing the drawing as shown.

Fig. 3 is another method for laying out a three-centered arch, and may be proceeded with by drawing the line *a b* $2\frac{27}{32}$ inches from the top border line, and a vertical center line *c d* $3\frac{3}{16}$ inches from the right-hand border line. Locate the points *a* and *b* to scale and at a distance apart equal to the span of the arch, likewise the rise of the arch *e f*. Divide the span into four equal parts, and from the points *g* and *h*, with a radius equal to *a g*, describe semicircles as designated. From the point *b*, with a radius equal to *b g*, describe the arc as shown, and where it intersects the vertical center line locate the point *d*; *d* will be the center from which to strike the arc *i f j*. The arcs *a i* and *j b* are portions of the semicircles previously described. Draw in the radial lines representing the joints between the voussoirs from their respective centers, and lay out the stonework to scale, as shown.

In drawing Fig 4, locate the springing line *a b* of the arch $4\frac{7}{16}$ inches above the lower border line, and the vertical center line of the arch *c d* $3\frac{3}{16}$ inches from the left-hand border

line; locate *a* and *b* by marking off the width of the opening to scale, and divide the span of the arch *a b* into four equal parts, thus locating the points *e* and *f*. With *b* as a center and a radius equal to *a b*, and with *a* as a center and with the same radius, describe the arcs as shown. Where they intersect the sides of the opening, will be located the points *j* and *k*. From *j*, with a radius equal to *j h*, describe the arc *g k*, and from *k*, with a radius equal to *k l*, describe the arc *g l*. From *e* and *f*, with a radius equal to *e l*, describe the arcs *a l* and *b h*. Complete the outline of the opening, and draw in the architrave mold to scale as shown.

In Fig. 5, the line *a b* is located $4\frac{7}{16}$ inches above the lower border line, and the vertical center line *c d*, $6\frac{1}{4}$ inches from the left-hand border line. Lay off the span *a b* to scale, and with *b* as a center, and a radius equal to *a b*, describe the arc *a e*; likewise from *a* describe the arc *b e*.

The line *a b* in Fig. 6 is also located $4\frac{7}{16}$ inches above the lower border line. Lay off in this figure the span *a b* to scale, and locate the point *e* at a distance of *e f* from the line *a b* on the vertical center line *c d*, which is located in the center of the sheet. Lay off this distance to scale, which, in this arch, is always greater than the span. Connect *a* and *e*, and bisect the line *a e* by the method described in Art. **28**, *Geometrical Drawing*, thus obtaining the line *g h* as designated. The point *h* will be the center from which to strike the arc *a e*, and *i* will be the corresponding center to the left of the vertical center line *c d*, from which to strike the arc *b e*. Draw in the architrave mold as shown in the figure.

In Fig. 7, the springing line *a b* is located the same distance above the bottom border line as the same lines in Figs. 5 and 6, and the vertical center line *c d* is $6\frac{1}{4}$ inches from the right-hand border line. Having located to scale the points *a* and *b* at a distance apart equal to the span of the arch, divide the span *a b* into four equal parts, locating the centers *e* and *f*. From *f*, with a radius equal to *f a*, describe the arc *a c*. From *e*, with the same radius, describe the arc *c b*, thus completing this figure.

Fig. 8 requires no special description. The line *a b* is located $2\frac{1}{32}$ inches from the lower border line, while the vertical center line *c d* is a portion of the center line in Fig. 5, extended. Draw the figure to scale as shown.

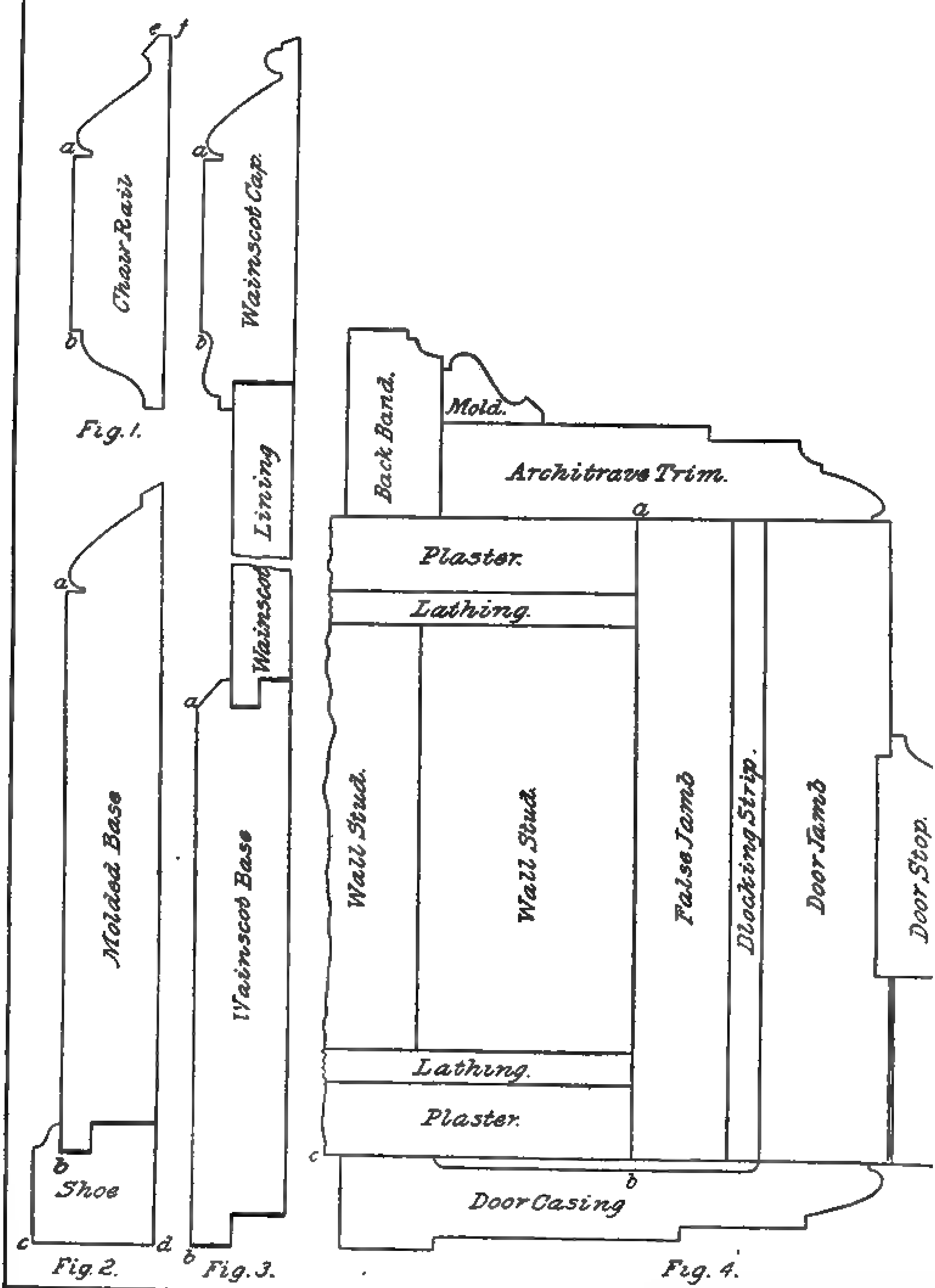
The segmental arch, Fig. 9, is laid out by drawing the springing line *a b* $2\frac{11}{32}$ inches from the bottom border line. The center line *c d* is a continuation of the same line in Fig. 6. Lay off to scale the span *a b* and the rise *e f*, and connect *a* and *f*. Bisect the line *a f*, and where the line *h g* intersects the vertical center line, as at *g*, will be the center from which to describe the arc *a f b*. Divide the arc *a f b* into twenty equal parts, and draw in the lines of the voussoirs that radiate from the point *g* and extend through the divisions just laid out.

Fig. 10 is simply a semicircular arch, designated as stilted because the line *a b*, upon which is located the center of the semicircle forming the arch, is some distance above the impost line *e f*. The line *a b* in this figure is a continuation of the line *a b* in Fig. 8, while the vertical center line *c d* is an extension of the same line in Fig. 7. Lay off the span and locate the center *g*, describing the semicircle *a c b*. Working to scale, finish the figure as shown.

The springing line *a b* in Fig. 11 is $2\frac{11}{16}$ inches above the bottom border line, while its vertical center line *c d* is $3\frac{3}{16}$ inches from the right-hand border line. Lay off the distance *a b* to the center line of the bead and divide it into six equal parts; also mark off the several divisions of the mold to scale; *e* and *f* will be the centers from which to strike the arcs *l g* and *m h*. The arcs *g k* and *h k* are struck from the centers *i* and *j*, which can be obtained in this particular case by scaling the distance *i g* and *h j*. These arcs are arbitrary; that is, they can be made to suit the taste of the designer. Draw in the mold as shown.

Having completed the plate in pencil, block out the title and proceed to ink in, giving the same values to the lines as are given on the plate. All reference letters may be omitted.

FULL SIZE DETAILS



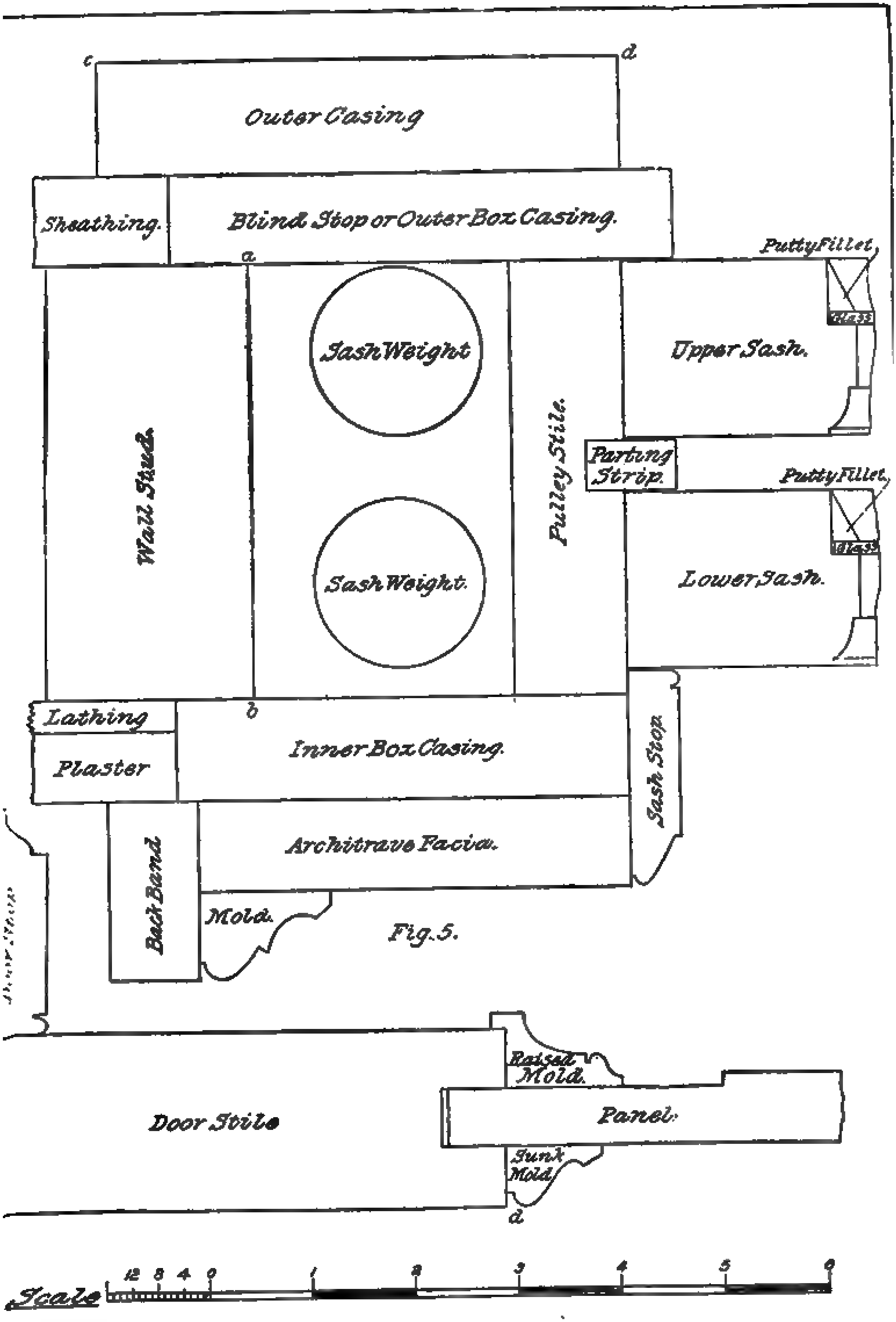

c
d
Outer Casing
Sheathing.
Blind Stop or Outer Box Casing.
Putty Fillet
Glass
a
Sash Weight
Upper Sash.
Wall Stud.
Pulley Stile.
Parting Strip.
Putty Fillet
Glass
Sash Weight.
Lower Sash.
Lathing
b
Inner Box Casing.
Plaster
Sash Stop
Back Band
Architrave Facia.
Mold.
Raised Mold.
Door Stile
Panel.
Sunk Mold.
d
Scale
12 8 4 0 1 2 3 4 5 6

Fig. 5.

DRAWING PLATE, TITLE: FULL-SIZE DETAILS

7. In the five figures upon this plate are shown the full-size details necessary to construct the interior trim of a well-constructed building. Since the details are laid out full size, the scale at the right-hand lower corner of the plate represents inches and parts of an inch, and in making the drawing, a 2-foot rule, or any scale having inch marks on it, may be used.

Fig. 2 shows a molded base provided with a shoe, and the chair rail, which would be used in connection with it, is shown in Fig. 1. The **molded base**, or, as it is sometimes called, the **baseboard**, or **skirting**, is the finish placed around the bottom of a wall or partition, and, resting on the floor, forms a protection for the plaster. The chair rail answers a similar purpose, being placed at such a distance above the floor as will prevent the back of a chair from striking the plaster and thus disfiguring it. The lines *a b*, Figs. 1 and 2, are laid out $\frac{1}{2}$ inch from the left-hand border line, while the base line *c d* of the shoe is $\frac{7}{16}$ inch from the bottom border line, and the top line *e f* of the chair rail is marked off $1\frac{1}{4}$ inches from the top border line. Having thus located Figs. 1 and 2, they may be drawn to scale, great care being exercised in order to obtain the correct profile of the moldings, as a slight deviation may cause them to lose character and consequently beauty.

Fig. 3 shows a complete wainscot excepting the shoe. The wainscot base takes the place of the molded base shown in Fig. 2, and the wainscot cap answers the same purpose as the chair rail designated in Fig. 1. The wainscot lining protects the plaster between the base and the cap, and forms a pleasing finish for the room. The lines marked *a b* in this figure are located $1\frac{3}{8}$ inches from the left-hand border line. The figure may now be laid out to scale and finished, as shown.

Fig. 4 is the sectional plan through a portion of a door and its jamb. The several parts are clearly marked, and need no explanation. The line *a b* in this figure is located

$5\frac{13}{16}$ inches from the left-hand border line, while the line cd is situated at a distance of $1\frac{6}{16}$ inches from the bottom border line. It will be noted in this figure that a different method of construction is shown on either side of the door, the same remark applying to the jamb. The architrave trim, shown in the upper portion of the figure, is only used where there is a back band. Having thus located the principal lines in this figure, the several parts may be drawn to scale.

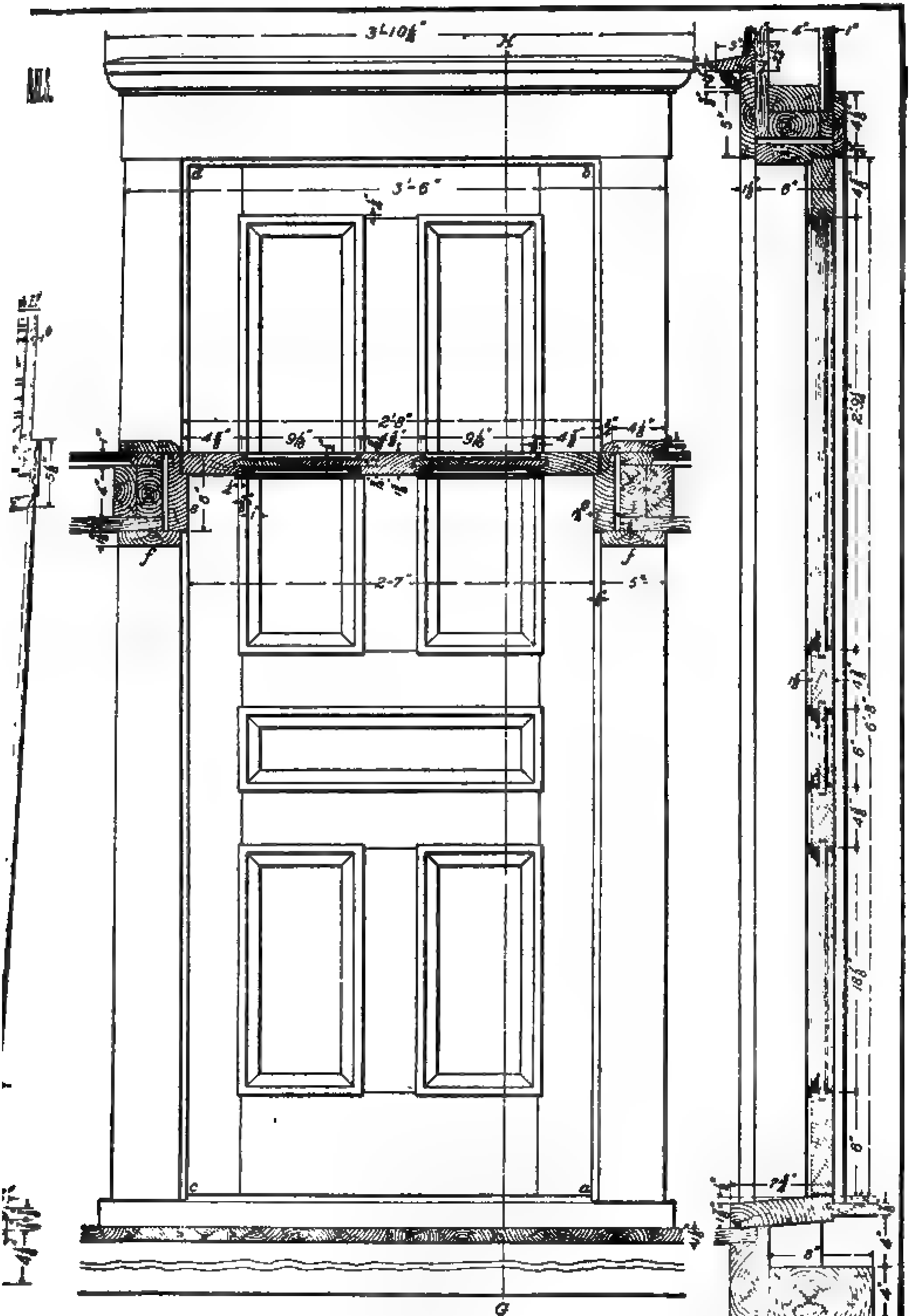
In order to finish the drawing plate, commence by laying off the line ab, Fig. 5, $6\frac{1}{4}$ inches from the right-hand border line, the line cd being $\frac{1}{16}$ inch from the top border line. This figure shows the usual method of constructing a window frame of an ordinary frame building or dwelling. The notes on the several parts make its construction sufficiently clear, and no further explanation is required, except that the student's attention is called to the fact that the wall stud in the window frame detail, Fig. 5, is made $4\frac{1}{4}$ inches instead of 4 inches, the usual size for studs of standard widths. Studs vary greatly in width, and the purpose of changing the width is to show the student that the window frames must be made to suit the actual width of the studs to which they are attached.

Ink in the plate with good, full lines that have the same value; no shaded lines are required on such a plate, since it is purely a working drawing.

DRAWING PLATE, TITLE: DETAILS

8. Fig. 1 of this plate shows an elevation, sectional plan, and vertical section of a **rear-veranda entrance door** for a frame house, and Fig. 2 shows the same views of a **window** of the ordinary double-hung sash type, for a brick wall with a straight stone lintel head.

Begin this plate with Fig. 1, drawing it to a scale of $1\frac{1}{2}$ inches = 1 foot. First draw the jamb lines ab and cd of the elevation 2 feet 7 inches apart, locating the line ab $2\frac{11}{16}$ inches



DOOR FOR WOODEN WALL.
Scale 1½" = 1 ft.

Fig. 1

Section Through G.K.

from the right-hand border line. Then draw the sectional plan across the elevation of the door, as shown, completing it before starting to draw anything else. Do this by drawing the section of the door first, which is $1\frac{3}{4}$ inches thick, with panels $\frac{1}{2}$ inch thick, and complete it from the dimensions given, proportioning the moldings of the door by the eye. Observe that the panel moldings on the outside face of the door are raised and lap a little over the edges of the stiles, while the moldings on the other side of the panels are sunk below the inside face of the door. Having finished the section of the door, now draw the frame of the door, first drawing the jambs *e*, *e*, which are $1\frac{1}{8}$ inches thick and 6 inches wide, with a $\frac{1}{2}$-inch rabbet; next, the outside casings *f*, *f*, which are $1\frac{1}{8}$ inches thick and 5 inches wide; and then draw the door studs, which are composed of two thicknesses of scantling 2 in. × 4 in., and complete this view from the dimensions given; this the student should be able to do without difficulty. Now start the vertical section (which is taken on the line *G H*) by first drawing the section of the door, the height of which is 6 feet 8 inches, and then drawing the remainder of the vertical section from the dimensions given. Locate the top edge of the door at a distance of $1\frac{7}{16}$ inches from the upper border line. Next draw the elevation of the door and frame. Do this by projecting all the perpendicular lines from the sectional plan and the horizontal lines from the vertical section, as these two sectional views give all the dimensions necessary. The student should experience no difficulty in completing this view.

Draw Fig. 2, the window for a brick wall, to a scale of $1\frac{1}{2}$ inches = 1 foot. Begin with the elevation of the window, by drawing the brick jambs *a b* and *c d* at a distance of 2 feet 10 inches apart, locating the jamb *a b* $1\frac{1}{4}$ inches from the left-hand border line. Then draw the bottom bed *e f* of the stone window sill at right angles to the jambs, and at a distance of $\frac{5}{8}$ inch from the lower border line. From the highest point of the stone window sill, which is $4\frac{3}{4}$ inches above the edge *e f*, as will be seen, lay off a distance of 4 feet $9\frac{3}{4}$ inches, and through it draw the lower side *g h* of the

stone lintel, completing both the lintel and the stone window sill from the dimensions given. Now draw the sectional plan of the window and the wall. This plan shows a section taken on the broken line $A\ B\ C\ D$, the left-hand portion of the plan being a section through the lower sash and the wall, and the right-hand portion, a section through the upper sash and the wall. Draw the brick wall first, which is 12½ inches thick, as shown; then draw the window frame and the sashes from the dimensions given, drawing the frame first. Draw the lines of the sashes to the center line $i\ j$ and stop them there. This is the general practice, as the sides of the sash and frame are alike, and half of the sash shows the construction of it as well as would the whole. Having finished this, draw the casing from the dimensions given. The two circles on each side of the window frame represent the sash weights. Now draw the vertical section of the window, which is a section taken on the line $E\ F$. Draw the brick wall first, projecting the lintel and the stone window sill from the elevation, and then the window frame and the sashes from the dimensions given, drawing the frame first. After this draw the casing from the dimensions given. All the small details of the construction should be plainly drawn and figured. Now complete the elevation, making use of the sectional plan and the vertical section, by projecting all horizontal lines from the vertical section and all perpendicular lines from the sectional plan. The brick-work is laid out in 2½-inch courses, that is, 2½ inches from center to center of joint. Complete the figure from the dimensions given.

9. The style of the section lines ordinarily used to represent wood cut across the grain is as shown in Fig. 1 of this plate. This is done by a series of irregular rings and radiating lines like the cross-section of an oak tree, which are to be made freehand with an ordinary writing pen.

The style of section line used to indicate plaster is also shown on this plate, and consists of a number of dots made freehand with an ordinary writing pen. The glass panes

are sectioned similar to brickwork. When it is desired to make the drawing show up well, some of the surfaces are slightly shaded. This has been done with the stone sill and lintel of the elevation in Fig. 2. Here the stone is shaded, and clearly shows its surface treatment. The margins are shown to be clean cut, while the remainder is rock face.

DRAWING PLATE, TITLE: MULLION WINDOW

10. This plate represents the detail drawings for a **mullion window,** consisting of the plan, exterior elevation, interior elevation, and vertical section, all drawn to the scale of $\frac{3}{4}$ inch = 1 foot, together with several sections of the moldings drawn full size. The window is constructed in a stone wall, the exterior being finished with cut-stone trimmings, while the interior in constructed to have splayed jambs. The openings are fitted with a wooden-box frame and double-hung sliding sash, but inside blinds, or shutters, are dispensed with, and the jambs, soffit, and breast are finished with framed, molded, and paneled linings. The window heads are segmental in form on the exterior, while the interior soffit is finished so as to be horizontal. An arch spans the opening between the jambs, to which a scantling of timber is attached horizontally on the interior, to serve as a base for the furring strips and plaster grounds.

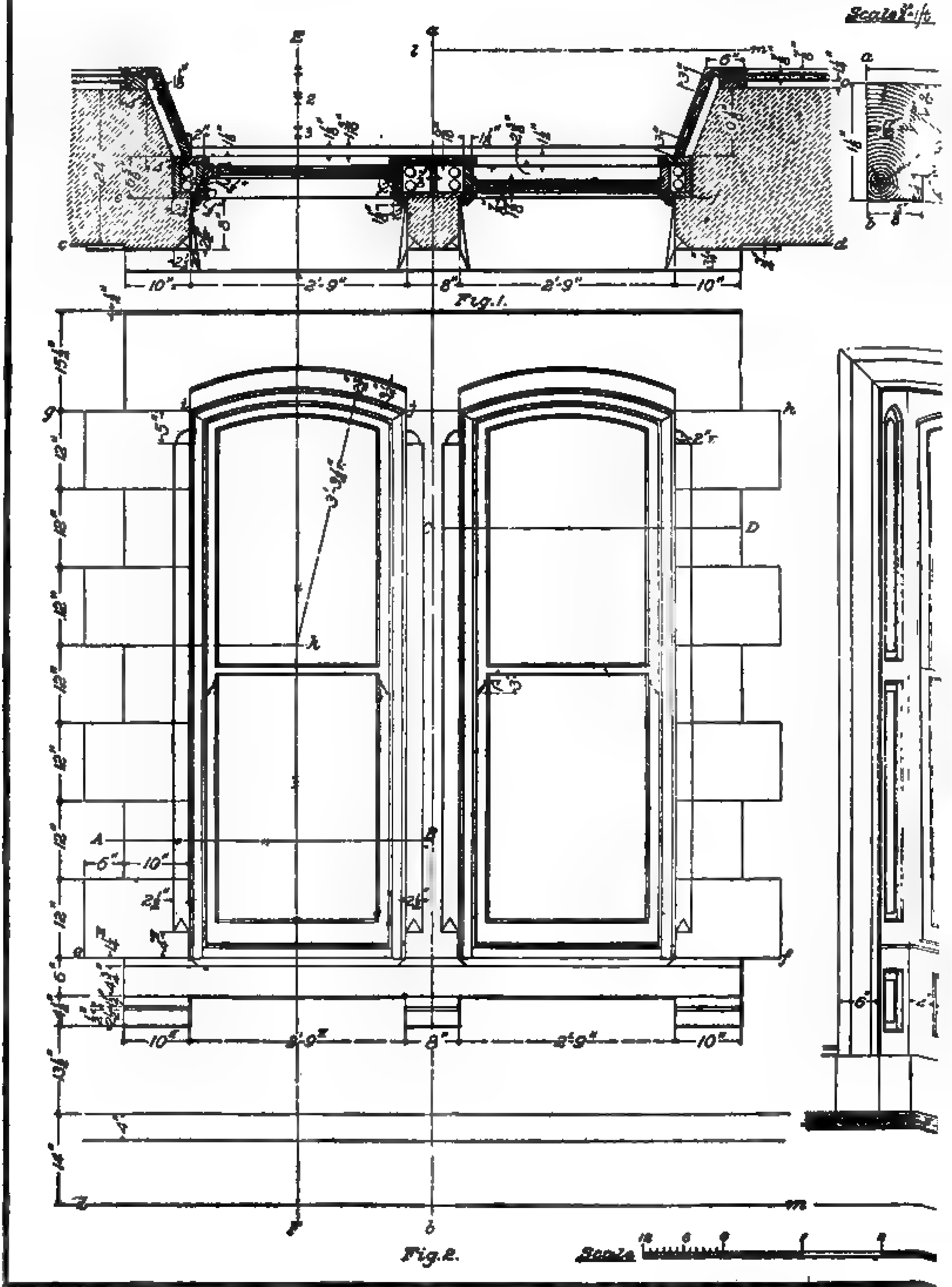
Begin Fig. 1, the *plan* (which is a horizontal section on the line $A\,B\,C\,D$ of Fig. 2), by drawing the center line $a\,b$ at a distance of $4\frac{1}{16}$ inches from the left-hand border line; draw $c\,d$, the outer face line of wall, at a distance of 8 inches below the upper border line. Each half of the plan is symmetrical, and that portion to the left of the center line $a\,b$ should be drawn first. Lay off, on the line $c\,d$, one-half the width of the *mullion*, or upright division between the openings; mark the width of the opening, and draw the reveal lines. Draw the face line of the trimmings, which is $\frac{1}{4}$ inch in advance of the line $c\,d$; make the depth of the reveal 8 inches, and draw $e\,f$, the outer face line of the box frame;

then form the rebate in the jamb in which the frame is placed.

From the line *c d* mark the thickness of the wall, which is 24 inches, and a space of 2½ inches additional for furring and for lath and plaster, as shown; then draw the horizontal lines, representing the plaster, etc., after which draw the splay of the jambs so that the inside of the opening is 4 inches wider on each side of the center line than the outside opening. From the line *e f* mark a series of points defining the members composing the thickness of the window frame, ⅞ inch for the outer casing, 1⅜ inches for the upper sash, ½ inch for the parting strip, 1⅜ inches for the lower sash, and 1⅜ inches for the width of the sash top; make the inner casing 1⅛ inches thick, and through the points marked, draw the horizontal lines defining the details as laid out. Draw the face line of the pulley stiles, which is 2 inches in advance of the stone reveal; mark 1⅛ inches for the thickness of each pulley stile, 2½ inches for the depth of the weight box, between the pulley stiles and back lining, and ⅜ inch for the thickness of the back lining; then draw the lines defining these details. Form the groove in each pulley stile ⅜ inch deep for the parting strip, and form the tongues on the pulley stiles which enter the inner and outer casings. Observe that the sash stop, parting strip, and edge of the outer casing are all in line. Make the width of the sash stiles 2 inches to the glass line, but add an extra ⅜ inch for rebate. (Fig. *H* shows a full-sized detail of this edge of the sash.)

Locate the vertical plaster ground at the inside edge of the splayed jambs, formed with a rebate to receive the lath and plaster, and draw the paneled jamb lining in position, a full-sized detail of which is shown in Fig. 1. Draw the inside trim, or casing, lapping over on the edge of the jamb lining and entirely covering the plaster ground; draw the line of the window breast 1⅛ inches inside of the frame and the line of the base, and the baseboard $\frac{3}{16}$ inch in advance of the paneling and casing. Draw the panel in the inside casing of the mullion, the sash weights in the box, the exterior

MULLION WI



/INDOW.

:/ft.

Fig.3.

Fig.4.

molding in the angle between the window box and the stone reveal, and then the line defining the front edge of the stone sill; draw the miter lines denoting the intersections of the sloping surfaces of the sill, and the chamfers formed by the cutting off of the corners of the quoins at the side of the mullion in the center. Having drawn the left half of the plan, draw the right half and complete the figure, observing that on the right-hand side the section through the elevation (Fig. 2) is taken through the upper sash, and therefore shows the sash on the right side of Fig. 1, in the exterior sash groove of the frame.

Begin Fig. 2, the **exterior elevation,** by drawing $e f$, the top line of the sill, at a distance of $3\frac{1}{8}$ inches above the lower border line, and draw $g h$, the springing line of the segment heads, at a distance of 7 feet above the line $e f$; project the reveal lines from Fig. 1, and from the points i and j, with a radius of 3 feet $3\frac{1}{2}$ inches, describe arcs whose intersection at the point k will locate the center from which the segmental curve may be drawn. Beginning at $l m$, the lower line of the base course, mark a series of points defining the heights of the base course, the sill blocks, and sill, the height of each quoin, and the lintel, and through the points so marked draw horizontal lines; make the width of the headers, or narrow stones, 10 inches, and the length of the stretchers, or wide stones, 16 inches; draw the vertical lines defining these stone details, and draw the chamfers on the angles of the jambs and mullions, with their top and bottom stops.

Before drawing the frames and sash in the elevation, it will be necessary to draw Fig. 4, which is a **vertical section on** the line $E F$ of Fig. 2. Draw $c' d'$, the vertical face line of the wall, at a distance of $2\frac{7}{16}$ inches from the right-hand border line; draw the face line of the quoins $\frac{3}{4}$ inch in advance of the line $c' d'$; lay off the thickness of the wall and the space for furring, and lath, and plaster, as in Fig. 1, and the thickness of the breast in the masonry under the sill, which is 12 inches, and draw the vertical lines. Project, from Fig. 2, the horizontal lines that mark

the stone courses and window opening, and transfer the lines defining the depth of the reveal, and the division of the box frame, by means of a strip of paper applied on the line *E F* of Fig. 1, which the lines of these details intersect. The various points should be carefully marked with a needle point on the paper strips, and then punctured in their positions on Fig. 4, after which the vertical lines can be drawn through them. Locate and draw the wooden sill of the frame, and the lower rail at the bottom, the meeting rails at the center, and the upper rail at the top of the sash, in accordance with the measurements given. Draw the $3'' \times 6''$ scantling under the arched head, which forms the support for the furring and plaster grounds; draw the floor joists and the double floor in position, as shown (the lower floor is laid over the joists diagonally, while the upper, or finished, floor is placed at right angles to the joists), and draw the furring and sheathing behind the stone breast of the window; draw the section of the paneled breast, and observe that the base is kept up $\frac{1}{2}$ inch above the finished floor, to allow the carpet to pass under it.

In order to draw the paneling, etc. of the jamb on Fig. 4, it will be necessary to project the lines of the jamb finish on Fig. 1 forward to *E F*, the line of section on which Fig. 4 is taken; this can be done by drawing from each detail of the panel jamb a horizontal line with the T square, and after marking the points so located, as shown at *1*, *2*, and *3*, transfer their relative positions by means of a strip of paper, as explained in connection with the reveal and window box. The vertical lines and the lines of the horizontal framing, etc. may then be located and drawn. Having now completed Fig. 4, return to Fig. 2, and draw the frames and sash in the window openings, projecting the vertical lines from Fig. 1, and the horizontal lines from Fig. 4, and describe the curves of the segment heads of the sashes from the same centers as were used for the stonework.

Begin Fig. 3, the **interior elevation** of the window, by drawing the center line *a b* at a distance of $6\frac{1}{16}$ inches from the right-hand border line; project the horizontal divisions

of the sash and inside finish from their respective positions in Fig. 4. In order to locate the vertical divisions, first draw the line *l m* in Fig. 1, at any position in advance of the wall line, and intersect *l m* by a series of perpendicular lines from the members of the frame, sash, and finish, marking their position on *l m* as shown; then transfer these points and their distance from the line *a b* by means of a paper strip to the inside elevation of Fig. 3; make the line *a b* on the paper strip coincide with the center line *a b* in Fig. 3, and prick the points with a needle, thus marking the divisions on one half of the elevation. The points on the other half can then be marked by reversing the strip, noting carefully that the line *a b* on the strip again coincides with the center line *a b* of Fig. 3. Now draw the vertical lines through the points as marked, and complete the figure by drawing the curved heads of the frame, sash, and finish, as shown.

Begin Fig. *G*, a full-sized section of the **exterior angle** molding of the frame, by drawing the line *a b* at a distance of $8\frac{3}{4}$ inches from the right-hand border line, and the line *c d* at a distance of $1\frac{7}{16}$ inches below the upper border line; draw the lines defining the width and thickness; then from the center *e*, with the radius given, draw the arc *f g*; join *e h*; from *h* as a center, with a radius equal to *h g*, draw the arc *g i*, of the length given; locate the center *j* and draw the arc *i k*; draw the quirk, or channel, between the molding and the fillet, and complete the figure. The center *e* may be located by striking an arc from *f* as a center, and with a radius of $\frac{21}{32}$ inch, and intersecting this arc by another drawn from *h* as a center and with a radius of $1\frac{21}{32}$ inches. The center *j* may then be located, so that the arc struck from it will be tangent to the arc *g i* and also to the bottom line of the molding.

Begin Fig. *H*, a full-sized section of the **edge of the sash,** by drawing the line *a b* $5\frac{1}{4}$ inches from the right-hand border line, and the line *c d* $1\frac{5}{16}$ inches below the upper border line; mark the thickness of the sash $1\frac{3}{4}$ inches; divide it into the members shown, and draw the horizontal and vertical lines. Draw the rebate for the glass and putty fillet on the

outside, and draw the molding on the inner edge, with a circular arc, as shown.

Begin Fig. *I*, a full-sized section of a portion of the **framed paneling** of the linings, by drawing the line *a b* at a distance of 2⅛ inches from the right-hand border line, and the line *c d* at a distance of $1\frac{5}{16}$ inches below the upper border line; draw the lines for the thickness of the framing, and form the groove for the panel. To draw the ogee molding, first locate the points *e* and *f* and join them with a line *e f*; bisect this line at *g*, and from *e* and *g* as centers, and with a radius equal to *e g*, describe intersecting arcs, from the point of intersection of which describe the arc *e g* with the same radius. The arc *g f* may then be drawn by the same process. The panel, which is $\frac{9}{16}$ inch thick, has a margin sunk ⅛ inch on its edges on one side, while on the opposite side the edge is beveled off to ¼ inch in thickness where it enters the groove in the stile; observe that the panel does not fill the full depth of the groove, this extra allowance of groove permitting the panel to swell without affecting the joints of the framing.

DRAWING PLATE, TITLE: DETAILS OF VESTIBULE

11. This plate represents the detail drawings for a vestibule, consisting of the floor and ceiling plans, the exterior and interior elevations, and a vertical section, all drawn to a scale of 1 inch = 1 foot.

The entrance doorway is constructed in a stone or brick wall, the exterior having cut-stone trimmings, finished with an angle mold. The entrance, or exterior, door is made in two leaves with rebated central joint, each leaf being hung flush with the jamb stop, and arranged to fold into a pocket, thus utilizing the full width of the vestibule. The pockets are finished with paneled linings, and the ceiling is finished with paneling to match the doors. The vestibule, or interior, door is made in one leaf, and fitted to rebated jambs, and the framing of the door is less in width at the glass panel than

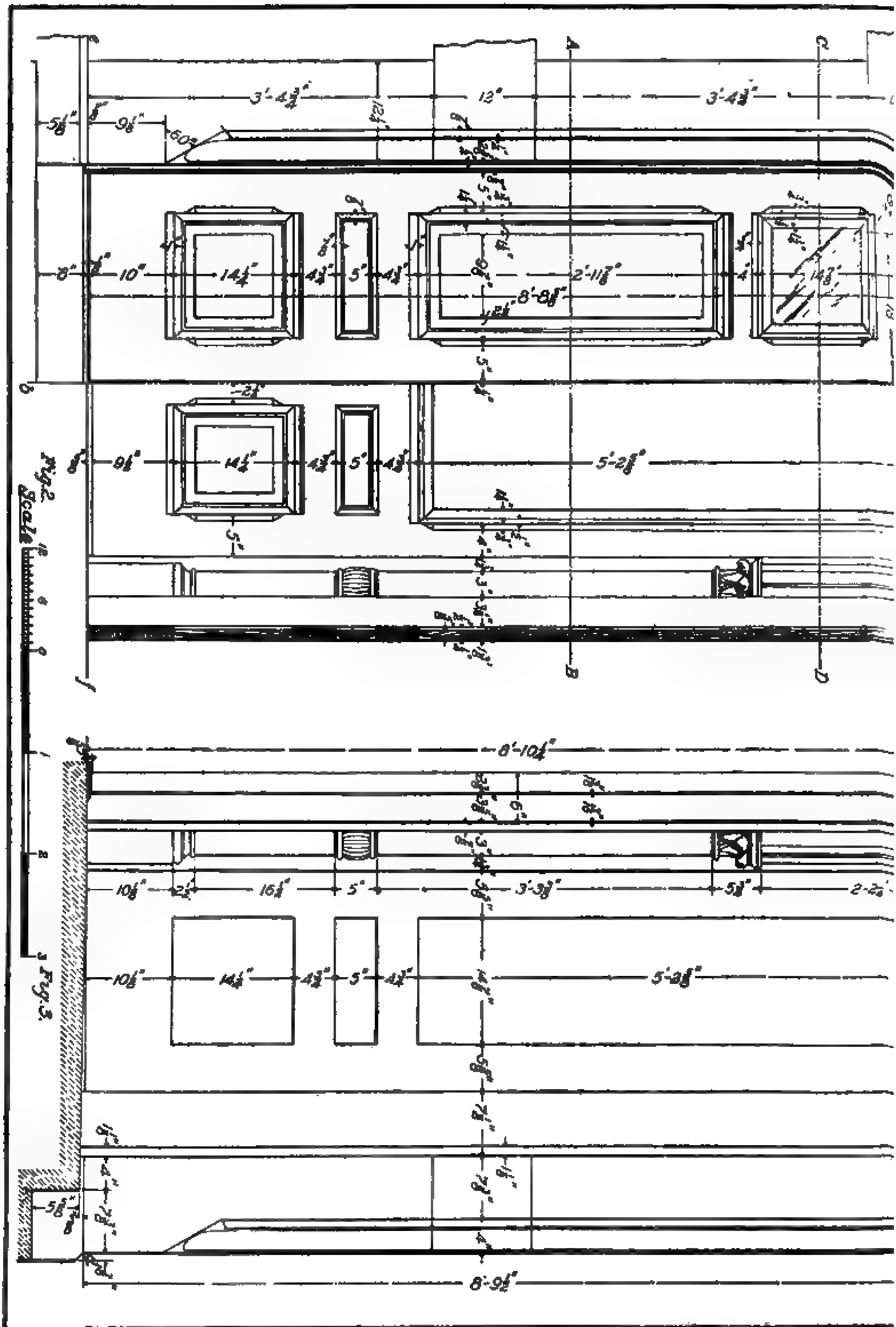


Fig. 2.
Scale
Fig. 3.

DETAILS OF VESTIBULE.

Scale 1" = 1 ft.

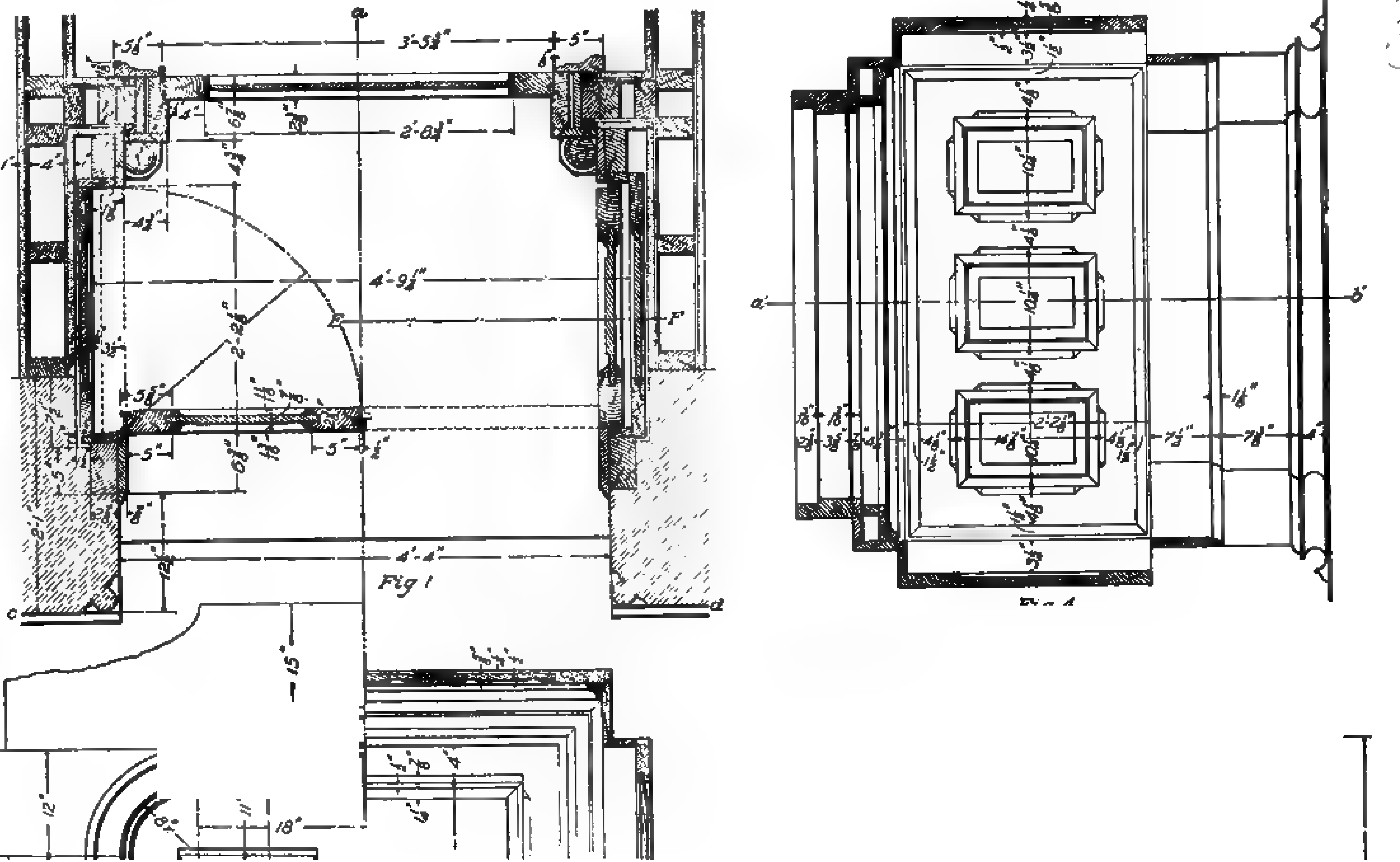


Fig 1

Fig 4

below. The exterior trim of the vestibule door is ornamented with a circular shaft and carved capital, which supports a molding; across the top, and part way down each side, the doors and paneled work are assumed to be veneered, and are therefore considerably thicker than would be the case if they consisted of but a single thickness of wood. The upper panels of both the entrance doors and the vestibule door are beveled plate glass.

After drawing the border line, commence Fig. 1, the **plan** (which is a horizontal section on the line *A B* of Fig. 2), locating the center line *a b* at a distance of 3¾ inches from the left-hand border line, and *c d*, the outer face line of the wall, at a distance of 6¼ inches below the upper border line.

Each half of the plan is symmetrical, and that portion to the left of center line *a b* may be drawn first. As the full opening in the masonry is 4 feet 4 inches wide, lay off one-half of this measurement to the left of the center line *a b*, and draw the reveal line and the angle molding, as shown; then, from the line *c d*, mark a series of points on the line *a b* defining the divisions of the reveal of the jamb in the masonry, 12½ inches for the stone reveal, 5 inches for the rebate to receive the door frame, and 7½ inches for the rebate to receive the pocket lining back of the door, making the total thickness of the wall 2 feet 1 inch; draw the door frame in the rebate 2⅞ in. × 5½ in. in section. The door stop, which is ⅞ inch thick, laps over on the stone and the inner casing, which is also ⅞ inch thick, covering the edge of the frame; draw in the entrance door, which is 2⅜ inches thick and passes ⅝ inch behind the face of the door stop. Locate the center of the hinge pin, which is assumed to be ⅝ inch in diameter, and describe a quarter circle indicating the swing of the door, as shown; draw the dotted outline of the door in its position when swung back in the pocket, and arrange the paneled lining behind same; locate and draw the vestibule door and frame, the section of the partition, casings, and trim by the measurements given; the door is 2⅜ inches thick, and the frame is 2 inches thick; then draw the angle shaft adjacent to vestibule door. That portion of

the plan to the right of center line $a\,b$ may now be drawn and the figure completed.

Begin Fig. 2, the left half of which shows the **exterior elevation** of the entrance door, while the right half shows the **interior elevation** of the vestibule; draw $e\,f$, the floor line, at a distance of $\frac{3}{4}$ inch above the lower border line; project the reveal of the left-hand jamb from Fig. 1, by drawing the line parallel to center line $a\,b$; lay off the courses composing the stonework of the jamb; mark the height of the lintel, and draw the horizontal lines; locate the center, and describe the curve of the corbel under the lintel, and from the same center draw a vertical line defining the end of the corbel; project the vertical lines of the angle molding from Fig. 1, and continue the molding around the corbel and across the door head on the lintel, as shown; then mark a series of points on the center line $a\,b$, defining the horizontal members of the door framing, and draw the lines; mark the width of the framing and draw the vertical lines; lay off the width of the moldings, the chamfers on the edge of the framing, and the margins of the raised panels, and draw the lines.

The student will undoubtedly notice that there are more members in the top mold of the principal and bottom panels than in the bottom mold. The ogee mold shown in the section continues around the panel, in each case being mitered at the corners. The bottom member, however, is in each panel a simple chamfer so as to readily shed water, and since the necessity does not arise so much at the top of the panel the mold here consists of a bead or half-round member having a **quirk,** channel, or groove at its upper edge.

Before drawing the right-hand portion of the figure, proceed with Fig. 3, the **vertical section** of the vestibule, by drawing $c'\,d'$, the face line of wall, at a distance of $\frac{3}{4}$ inch from the right-hand border line; produce $e\,f$, the general floor line, from Fig. 2, and on it mark a series of points defining the vertical lines of the stone reveal and jamb stop, the paneled lining of the door pocket, the shaft and hood mold composing the exterior trim of the vestibule, the door

frame, interior trim, etc., and draw them; on the line $c'd'$ mark a series of points defining the horizontal divisions of the paneled lining, the shaft with its base, band, and capital, the head of the door frame, hood mold, ceiling paneling, angle molds, etc., and draw the lines; draw the angle mold at the ceiling and on the stone jamb by means of the bow-pencil, the carved capital of the shaft, the pedestal band, and the other moldings to be drawn freehand; draw the floor line of the vestibule, which has a pitch of $\frac{1}{8}$ inch from the saddle of the vestibule door, and also draw the line of the platform in front of the door step, and complete the figure.

Now draw the right-hand portion of Fig. 2, the interior elevation of the vestibule taken on the line EF of Fig. 1; project the horizontal lines from Fig. 3, and the vertical lines from Fig. 1; arrange the paneling in the framing as shown; project the horizontal lines of the door framing from the entrance door; mark the width of the vertical framing and the top rail, and draw the lines; draw the molded and carved work and complete the figure.

Begin Fig. 4, the **plan of the ceiling**, as seen from below, and taken on the line cd, of Fig. 2, by drawing the center line $a'b'$, at a distance of $3\frac{5}{8}$ inches from the upper border line; project the vertical lines from Fig. 3, and from the center line $a'b'$ lay off and draw the horizontal divisions of the paneling, the door frame, hood mold, door pockets, etc., and complete the figure.

DRAWING PLATE, TITLE: STEEL COLUMNS AND CONNECTIONS

12. In this plate are shown two designs of columns used in the construction of modern office buildings, and a common method of connecting the floorbeams to the columns is shown. A side view and a front view of each design is given, and as it would manifestly be impossible to draw the columns in their full length, and since, besides, it would not serve any useful purpose to do so, a part of the column between the base and the floorbeam connection is broken

away. When this is done, it is understood that the part broken away is similar to the ends of the column next to the break, which in this case is indicated by drawing a line consisting of a long dash and two dots across the column. Among mechanical draftsmen it is customary to indicate a break by a wavy freehand line, but many architectural draftsmen indicate a break in the manner shown in this plate. The student's attention is also called to the fact that the style of lettering used for the title and notes differs somewhat from the preceding plates. The construction of the letters in both the title and the notes is explained in *Geometrical Drawing*. The lettering on this plate is more consistent with the class of work shown, but the student may use the more ornamental type for the heading and the single line italics for the notes employed on the other plates, if he prefers.

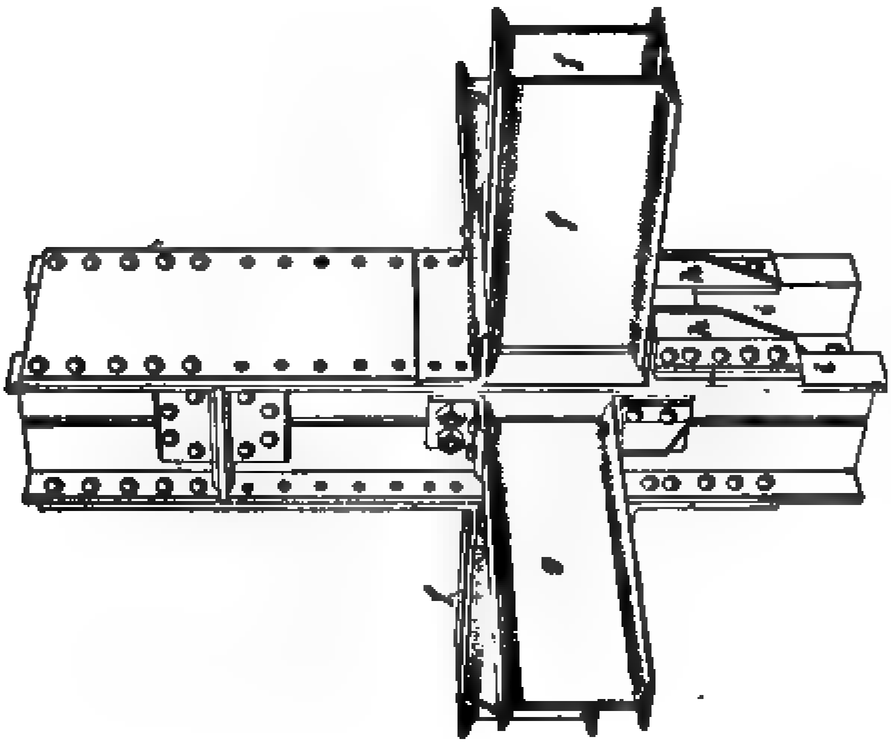
In the design shown in Fig. 1 of the plate, and in perspective in Fig. 4 (*a*), the column consists of two 15-inch channels *a*, *a* placed back to back and tied together by cover-plates *b*, *b*, 12 inches wide. The column is supported on a steel bedplate 24″ × 25″ × ⅞″, to which it is attached by side plates *c*, *c* and angle irons *d*, *d* riveted securely to the bedplate. Each channel, for further security, is tied to the bedplate by an angle iron, as *e*. The column supports two pairs of longitudinal floorbeams *f*, *f*, *f*, *f* and two transverse floorbeams *g*, *g*. Each pair of longitudinal floorbeams is supported on a horizontal bracket made from a 5″ × 5″ angle iron *h*, and stiffened by two 4″ × 3″ angle irons *i*, *i* placed back to back. A filling piece *j* is placed between the cover-plate and the lower part of the angles *i*, *i*. The longitudinal floorbeams are tied on top to the column by a 5″ × 5″ angle iron *k*. Each transverse floorbeam rests on a bracket made from a 4″ × 6″ angle iron *l*, stiffened by a 3″ × 2½″ angle iron *m*, placed as shown. A 4″ × 4″ angle iron, as *n*, ties the top of these floorbeams to the column by means of two ¾-inch bolts. The column is made in sections, the lower section being 22′ 8″ high. The upper section is spliced to the lower section by the vertical splice

STEEL COLUMNS

S AND CONNECTIONS.

NOTE

plates *o*, *o*, a horizontal splice plate *p*, and 5″ × 3″ angle irons *q*, *q*.



(*a*)

FIG. 4

(*b*)

The column shown in Fig. 2 of the plate, and in perspective in Fig. 4 (*b*), is built up from four **Z** bars *a*, *a*, *a*, *a*

securely riveted to a web-plate *b*. Since the edge *a'* is the dark edge of a recess, it should be shaded, according to the rules of shading. On referring to Fig. 2 of the plate it will be found that the line corresponding to *a'*, Fig. 4 (*b*), is made a light line instead of a shade line, as it should be. This is a conventionalism adopted frequently by experienced draftsmen, who will omit a shade line when its presence will render the drawing, or part of it, indistinct instead of clearer. It is readily seen that if the line mentioned is shaded on Fig. 2 of the plate, it will not be possible to show correctly the thickness of the web of the **I** beam; hence the line is left light. The column, as shown in Fig. 4 (*b*), is supported on a steel bedplate 21¾″ × 31½″ × ⅝″, to which it is attached by the side plates *c*, *c* and angle irons *d*, *d*. For further security each pair of **Z** bars is tied to the bedplate by an angle iron, as *e*. Two pairs of longitudinal floorbeams *f*, *f*, *f*, *f* and two transverse floorbeams *g*, *g* are connected to the column in practically the same manner as those shown in Fig. 4 (*a*). A slight difference in the construction of the brackets supporting the longitudinal floorbeams will be noticed. Instead of using a single filling piece under the two stiffeners *h*, *h*, a separate filling piece, as at *i*, *i*, is used under each stiffener. Each transverse floorbeam is supported on a bracket made from a 4″ × 6″ angle iron stiffened by a 3″ × 2½″ angle iron, and is tied on top by a 4″ × 4″ angle iron riveted to it and bolted to the column. This column, like the other column, is built in sections, the upper section being spliced to the lower section by two vertical splice plates, one horizontal splice plate, and angle irons. It will be noticed that the manner in which the splice is made is identical with that used to splice the sections of the column shown in Fig. 4 (*a*).

In the drawings there will be noticed several conventionalities. There are a number of rivet holes shown black in the side views (the views having the center lines *c d* and *g h*) of both designs. This indicates to the shop men that the rivets destined for these holes are so-called **field rivets**; that is, they are to be driven in at the place where the structure

is being erected and after the columns are in place. The position of the field rivets is indicated in the front views (the views having the center lines *a b* and *e f*) by blackening in the *position* of the holes. According to the rules of drawing, their position would be shown by dotted lines, but the conventionalism of blackening in is resorted to as better calling the attention of the workmen to the fact that the rivets destined for these holes are field rivets. This common usage is departed from only in the case where the parts through which the field rivets pass are hidden behind some other parts of the structure. Thus, referring to the front view of Fig. 1, field rivets are shown as passing through the plate and two angle irons at the splice, and as neither the plate nor the angle irons are hidden, their position is shown in black. In the side view, however, the horizontal plate at the splice is hidden behind the splice plate, and the angle irons are hidden behind the splice plate and the legs of the channels; consequently, the field-rivet positions are shown in this view by dotted lines.

All the rivets that are to be driven in the shop where the column is made are shown in position; in some drawing rooms, in order to save time, the rivets are omitted, their position being merely indicated by two center lines. In order to show the rivets clearly, their heads are shaded a little in the manner shown, using the bow-pen for the shading.

The dimensions of the channels, I beams, and Z bars are not given in detail, this not being necessary on a working drawing. All that is required is to give the size of the channel, etc. The notes giving the sizes are read as follows: On the front view of the left-hand design we find a note "2–15″–33–22′–$7\frac{3}{8}$″ ["; this means two 15-inch channels, 33 pounds per foot of length, 22′ $7\frac{3}{8}$″ long. The note on the front view of the right-hand design, "4–6″ × $3\frac{1}{2}$″–22.7–Z Bars," means that four Z bars having a depth of 6 inches, legs $3\frac{1}{2}$ inches wide, and weighing 22.7 pounds per foot of length are to be used. The note, "2–12″–40–I Beams," means that two 12-inch I beams weighing 40 pounds per foot of length are to be used. The note, "4″ × $3\frac{1}{2}$″ × $\frac{7}{16}$″ × $11\frac{1}{8}$″ Angle,"

means that an angle iron with legs measuring 4 inches and $3\frac{1}{2}$ inches, $\frac{7}{16}$ inch thick, and $11\frac{1}{2}$ inches long is to be used.

In order to aid the student in drawing the various parts the dimensions of which are not fully given on the plate, sectional views of them, fully dimensioned, are given in Fig. 5 of the text.

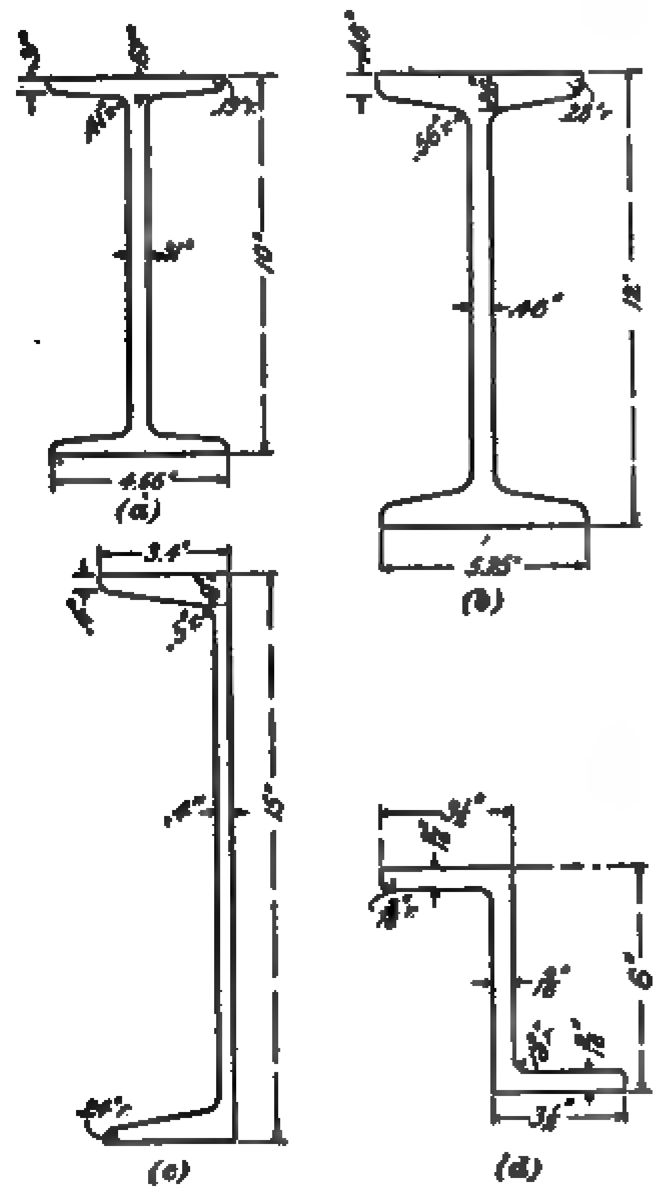


FIG. 5

The section of the 10-inch I beam is given in Fig. 5 (*a*), of the 12-inch I beam in Fig. 5 (*b*), of the 15-inch channel in Fig. 5 (*c*), and of the Z bar in Fig. 5 (*d*).

In Fig. 5 (*a*), (*b*), and (*c*), the dimensions are given in decimals, or as they appear in the catalogue of the rolling mill. Since it is practically impossible to lay off these decimal dimensions to a scale of $1\frac{1}{2}$ inches = 1 foot, it is recommended to use the nearest sixteenths of an inch, taking $.19 = \frac{3}{16}$, $.24 = \frac{1}{4}$, $.28 = \frac{1}{4}$, $.31 = \frac{5}{16}$, $.40 = \frac{3}{8}$, $.41 = \frac{7}{16}$, $.46 = \frac{7}{16}$, $.56 = \frac{9}{16}$, $.66 = \frac{11}{16}$, $.67 = \frac{11}{16}$, $.86 = \frac{7}{8}$, $.90 = \frac{7}{8}$.

All rivets in these two designs are $\frac{3}{4}$ inch diameter, having a head $1\frac{1}{4}$ inches in diameter and $\frac{9}{16}$ inch high. The holes to receive the rivets are generally punched $\frac{1}{16}$ inch larger than the shank of the rivet (the size of a rivet is denoted by the diameter of the shank *before* the rivet is

driven), so that the rivet holes for $\frac{3}{4}$-inch rivets are punched $\frac{13}{16}$ inch diameter. As a matter of course, the rivet when driven fills the hole, so that the *driven* size of a rivet = nominal size + $\frac{1}{16}$ inch.

To draw the plate, begin by drawing the center lines, locating $a\,b$, $c\,d$, $e\,f$, and $g\,h$ respectively $2\frac{7}{16}''$, $6\frac{1}{4}''$, $10\frac{11}{16}''$, and $14\frac{9}{16}''$ from the left-hand border line. The top line $K\,L$ of the floorbeams is to be located $7\frac{5}{16}''$ and the bottom $i\,j$ of the bases $\frac{15}{16}''$ above the lower border line. The floorbeams are shown broken off, and should be made about the same length in proportion to their depth as they appear on the plate.

The reference letters printed in bold-face italics are to be omitted on the drawing made by the student.

DRAWING PLATE, TITLE: FIRST-STORY PLAN

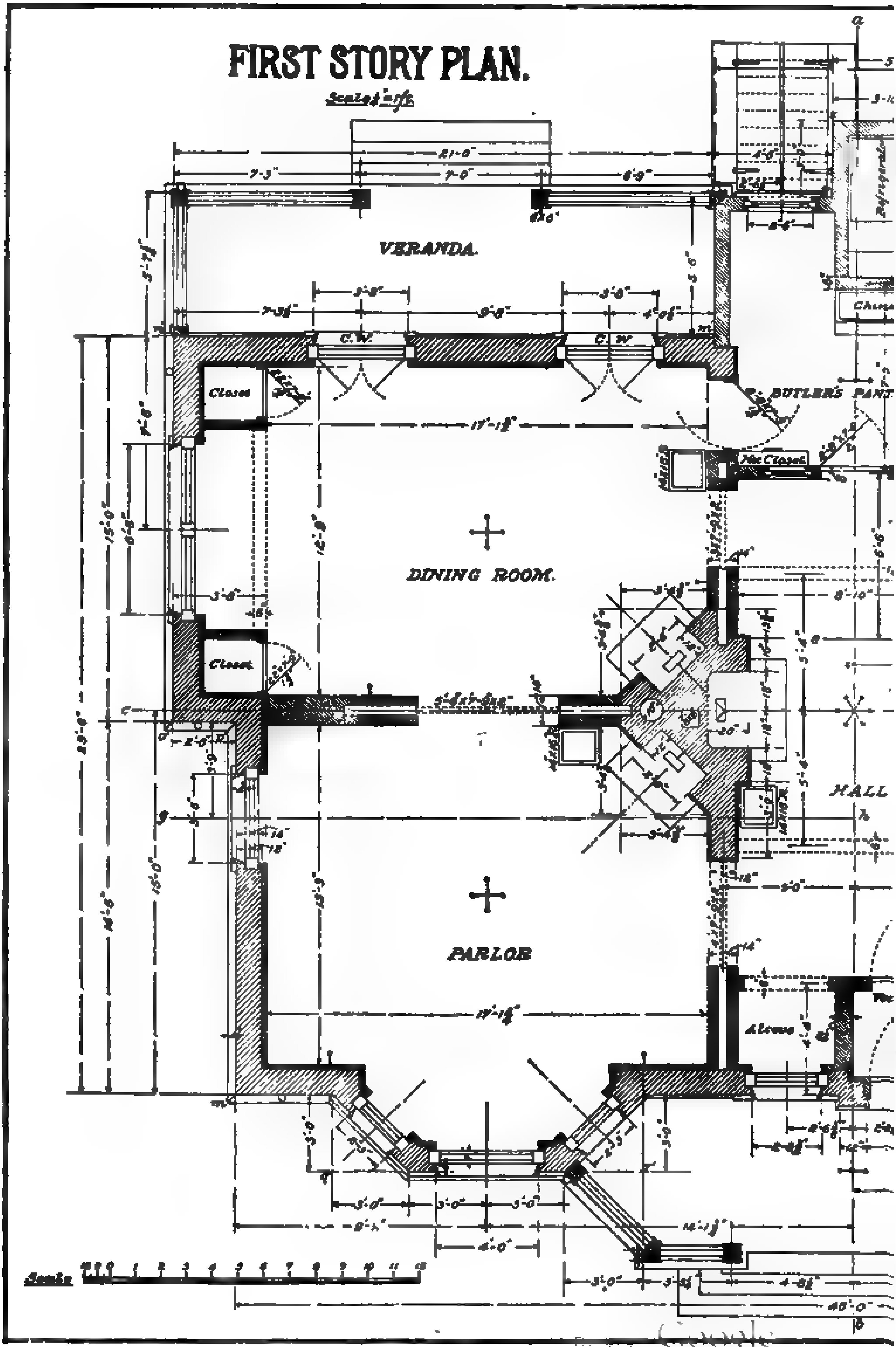
13. The five following plates will be devoted to the general drawings and details of a **two-story brick-and-frame suburban residence.** The next plate, the **first-story plan,** is to be drawn to a scale of $\frac{1}{4}$ inch = 1 foot. This is what is called a *working drawing*, and shows the form in which a house plan should be drawn and figured, in order to estimate the material and erect the building.

Begin by drawing the center line $a\,b$ at a distance of $8\frac{1}{8}$ inches from, and parallel to, the left-hand border line; draw the center line $c\,d$ at right angles to it and at a distance of $6\frac{1}{8}$ inches from the lower border line; then draw the center line $e\,f$ parallel to $c\,d$ and at a distance from it, by scale, of 2 feet $9\frac{1}{2}$ inches. These center lines will constitute the base lines of measurement, from which the arrangement of the plan will be developed. Measurements from these lines to locate points must always be on a line at right angles thereto. To locate the exterior angles of the building, proceed as follows: Beginning with m, measure 15 feet from center line $c\,d$, at right angles to it, and draw the face line $m\,n$ of front wall; then from a point 23 feet $10\frac{3}{4}$ inches from center

line *a b*, draw the face line of the return wall *m p'*; the intersection of the two face lines will locate angle *m*. The lines should first be drawn to an indefinite length, their limits being defined as the angles are located. At a distance of 5 feet $7\frac{1}{4}$ inches from center line *a b*, locate *n* on the face line of front wall; from *n* draw line *n o* at right angles to line *m n*, and at a distance of 18 inches from, and parallel to, line *m n* draw the face line *o p* of wall. Locate *p* at a distance of 22 feet $1\frac{1}{4}$ inches from center line *a b*. From the point *p* just found, draw the face line of the wall *p q* at right angles to line *o p* for a distance of 20 feet 1 inch; thence, at right angles to line *p q* and parallel to line *e f*, lay off a distance of 12 inches to *r*. Draw face line of wall *r s* parallel to center line *a b*, *s* being at a distance of 16 feet 5 inches from *r*; then draw face line of wall *s t* 10 feet $5\frac{1}{4}$ inches long and parallel to center line *e f*. At *t* the wall recedes 19 inches; draw *t u* at right angles to line *s t*; draw *u v* parallel to *s t* 7 feet 8 inches long from angle *u*; draw *v w* equal and parallel to *t u*; draw *w x* in line with *s t*, and lay off *x* 5 feet $10\frac{3}{4}$ inches from *w*. Draw face line *x y* parallel to center line *a b*, locating *y* 3 feet from *x*; from *y* draw face line *y z* parallel to center line *e f*, *z* being 4 feet 6 inches from angle *y*. From angle *z* parallel to center line *a b* draw face line of wall *z m'*, *m'* being at a distance of 5 feet 6 inches from angle *z*. From *m'* draw the face line of wall *m' n'* parallel to center line *c d*, *n'* being at a distance of 21 feet from angle *m'*. From *n'* draw face line of wall *n' o'* parallel to center line *a b*, *o'* being at a distance of 15 feet from angle *n'*. From *o'* draw face line of wall *o' p'* parallel to center line *c d*, *p'* being at a distance of 2 feet 6 inches from angle *o'*. The intersection of line *o' p'* with line *p' m* will locate angle *p'*.

The angles defining the main outline of the building being now located, proceed to establish the face lines of the bay window in the parlor and the curved wall of the library. Draw the center line of the bay window at a distance of 9 feet 9 inches from, and parallel to, face line *m p'*; then draw front face line of window 3 feet from, and parallel to, face line *m n*.

FIRST STORY PLAN.



At a distance of 3 feet from each side of the center line, and on the face line of window, locate the angles. At a distance of 6 feet from each side of the center line locate points q' and r', and draw from each of these points a line at right angles with face line $m n$; the intersection of these lines with $m n$ will form the *reentering* angles of the window. To locate the center from which the curved wall of the library is described, measure 5 feet on the face line of wall $o p$ from angle p and mark a point; on face line $p q$ measure 5 feet from angle p and mark a point; from each of these points, and at right angles to the lines on which they are marked, draw an indefinite line; these lines will intersect at s'. From s' as a center, with a radius of 6 feet 6 inches, describe an arc which will intersect the face lines $o p$ and $p q$ as indicated. Now draw the face line and returns of the entrance doorway. The face line advances 5 inches from the wall-face line $m n$. Draw the center line of doorway parallel to and 2 feet $2\frac{1}{2}$ inches from the center line $a b$, and locate the jamb stones as shown; the width of the opening being 3 feet 5 inches, the distance of each jamb from the center line will be one-half of this, or $20\frac{1}{2}$ inches. Make the width of each jamb on the face line 12 inches, and draw in the returns at right angles from the face line. The complete outline of the building proper being now finished, draw the inner face line of all the walls already outlined, noting carefully that the thickness given for brick walls is 12 inches, and for timber walls 7 inches. (The thickness of brick walls varies from 12 inches to 13 inches, according to the size of brick used. The former is here adopted.) Set the bow-pencil to 12 inches by scale, and draw a quadrant arc at the angles m, n, o, p, q, etc., taking the vertex of the angle as the center; tangent to these arcs and parallel to the face lines, draw the inner face lines of walls. The intersection of these lines will define the interior angles. The position of the plaster line in the rooms should be determined in the same manner by increasing the radius to describe the arcs to 14 inches, which will be an allowance of 2 inches for furring and plastering. The width of the clear opening for

the bay window being 9 feet 6 inches, measure 4 feet 9 inches from each side of the center line; this will give the reveal line which intersects with the side wall of window. Follow the same method for laying off the thickness of timber walls, which is 7 inches, of which 5 inches is allowed for the wall studs, or uprights, 1 inch for outer boarding, and 1 inch for plastering. It will be observed that, at the junction of the timber walls with the brick walls, a recess is formed in the brickwork to allow the timber wall to pass over it; this forms an air-tight connection and a secure joint.

Having finished the outer walls, proceed to locate the inner walls, or *partitions*, as they are called. Draw the center line of the partition to the left of the center line $a\,b$, 5 feet from and parallel to it. Since this partition is 14 inches thick, lay off 7 inches on each side of the center line, and draw the face lines of partition parallel to the center line. Now draw the brickwork of the chimney construction, first laying off the dimensions on each side of the center line $c\,d$ to locate the fireplace in the hall; after which mark off the width of brickwork, which extends into the rooms from the face of the partition 3 feet $4\frac{1}{2}$ inches, as shown. Make this line parallel to center line $a\,b$, and on it lay off on each side of $c\,d$ a distance of 3 feet $11\frac{3}{8}$ inches, drawing through the extremities lines parallel to the center line $c\,d$. From the points of intersection of these lines with the walls, draw the face line of the room fireplaces at an angle of 45°; on each side of the diagonal that defines the center line of the fireplaces, lay off one-half of the opening, which will be 15 inches. Make the depth of the fireplace 12 inches, and draw the position of the ash chute in each fireplace and the flues in the brickwork, the flue, which is 10 inches in diameter, being a hot-air duct, and the $8'' \times 8''$ flue being for the furnace in the cellar. Draw, also, the outline of the hearths, taking sizes with the dividers, which, applied on the scale at the bottom of the drawing, will give the measurement. It will be observed that the wing wall of the brickwork is extended to the jamb of the parlor doorway, while on the opposite side the wall is constructed to form the pocket for the sliding door. The

line which is drawn 1 inch from face of brickwork indicates the face line of plastering. Now draw the partition between dining room and parlor, the face lines of which will be 7 inches from the center line *c d*, and also the partitions enclosing the closets in dining room to dimensions shown; the dotted lines connecting same denote the ceiling beam overhead.

No door or other openings should be located in the partitions until they are all drawn in. Now draw the center line of the hall and kitchen partition to the right of the center line *a b*, which, as shown, is 4 feet 8 inches from *a b*; from this line, lay off on each side 3 inches, which is one-half of the thickness of the partition, and draw the face lines parallel to *a b*.

Now draw the center line of the partition in which the vestibule door is located, which in this case is 4 feet 4 inches from outer face line of wall, and lay off the face lines of partition by the process already described; afterwards draw the vestibule partition parallel to center line *a b*. Then draw the center line and locate the partition between the butler's pantry and hall from the dimensions given, and also draw in the partitions that enclose the pantry. Now locate the ceiling beams in the hall, which are denoted by the dotted lines on the plan. From the center line *e f* lay off on each side, at a distance of 4 feet 1½ inches, the center lines of the stair-hall partitions, and make these partitions of the thickness shown. Now draw the partitions enclosing the kitchen stairway from the dimensions given, first locating the center lines, afterward drawing the partitions enclosing the two closets in the angles of the kitchen, as shown. Then draw in the brickwork of the kitchen-chimney construction, first locating the center line of the fireplace 7 feet from and parallel to the outer face line of the wall, and lay off the face line of the fireplace 2 feet 10 inches from the outer wall face, on which mark the jamb lines 23 inches from the center line, and their width on the face of 12 inches. From the face line of the fireplace lay off the depth 20 inches, drawing the jamb lines parallel to the center line, and make the thickness

of the back wall 8 inches, which will bring the brickwork against the studs of the framework of wall, as shown. Increase the width of jamb in the closet, and construct an $8'' \times 8''$ flue, the least thickness of the wall shown being 4 inches. This flue is arranged for the laundry stove.

Having now finished the outline of the partitions, proceed to locate the door openings in them; where they are on, or adjacent to, center lines, always measure from them; otherwise, find their positions from the angles of the room by the dividers, which, applied to the scale on the engraving, will establish their correct position on the drawing. First find the position of the jamb next to the adjacent angle, set the dividers to the width of the door, and lay off the opposite jamb. Note carefully that the center line of the sliding-door opening between dining room and parlor is in line with the center line of bay window; that the center of vestibule door is in line with that of the entrance doorway; that the center line of the door opening between hall and library is the diagonal, drawn at an angle of 45° from the intersection of the hall side of the partitions. The center line of the door to butler's pantry is on the center line *a b*; the center line of the door from hall to parlor is midway between the ceiling beam and the vestibule partition. It will be observed that the jambs for folding doors are rabbeted, or checked, for the full thickness of the door, so that the opening is 1 inch less than the width of the door, that is, ½ inch advance on each side. After the openings for folding doors are located, draw in the arcs with dotted lines, as shown, defining the edge on which the door is hung, and draw in the full line denoting the open door, as shown, at an angle of 45° from the wall face. The size and thickness of doors are not to be written in until all the line work is completed. The double-action door between the butler's pantry and the dining room is shown with a large arc, which denotes the double swing of the door. Draw in the position of sliding doors in their respective openings with dotted lines and the pockets in partitions for their reception, and draw the sash openings on each side of hall door to butler's pantry, as shown.

Having completed the openings in the partitions, proceed to draw the main stairway. First draw the center line of the straight portion of the hand rail of the first flight, which is 3 feet 6 inches from and parallel to the face line of partition. From this center line lay off the center line of the rail of return flight, which is 12 inches from it and forms what is called the *well* of the stairs. Then draw the center line of the platform newels, which is 3 feet 6 inches from, and parallel to, the wall face. From this center line measure a distance of 7 feet on the center line of the first-flight hand rail, and mark a point. This will define the limit of the straight portion, or tangent. At this point erect a perpendicular line, on which lay off a distance of 6 feet 1½ inches. With this length as a radius, describe the curved center line of hand rail, as shown; at the point where the curve leaves the tangent, with a radius of 3 feet, describe an arc intersecting the first curve, which will define the center of the start newel, which is 7 inches square. Draw this newel by first describing a circle 7 inches in diameter; then draw the square outline. The face against which the hand rail abuts will be on a radial line of the first curve. Draw the adjacent faces perpendicular to it, and the opposite faces parallel to it. Now locate the platform newels and the newel at the floor landing, which are 5 inches square, by describing circles 5 inches in diameter, and then circumscribing squares. It will be observed that the center of the newels is at the intersection of the riser lines with the center lines of the hand rail. Next draw in the lines that represent the risers. Beginning at the center line of the platform newels, lay off, with the dividers set to 10 inches, the width of step, or tread, between riser and riser, on the center line of the hand rail of the first flight, a series of points, as far as the straight risers extend. From these points draw in the riser lines at right angles to the center line of the hand rail and project them over to the second flight, as shown. Now draw the curved riser lines by first locating their intersection with the curved center line of the hand rail, and then draw a line in the center of the width of the stairs, finding their width on this

line by applying the dividers to the scale on the engraving. Mark these points on the drawing; then mark the points that define the width at the partition line. Three points having been plotted for each curved riser, join them with an irregular curve. Draw the outer line around the start newel, which indicates the base on it, and from the center line of the hand rail lay off the fine lines that indicate the members of the hand rail. Draw them parallel to the center line. Break off with an irregular line, as shown, which denotes the finished stair broken off to allow the floor arrangement underneath to be shown. Draw in the paneled partitions that enclose the lavatory, including the doorway. It will be observed that the stair lines beyond this break are shown in dotted outline, which denotes that they are represented in a plane occupying a higher level than that on which the other objects are shown. The representation of this stairway is now complete so far as the requirements of the floor plan are concerned. Now draw the portions of the stairway from kitchen to landing level of main stairway and the stairway to cellar as shown. Begin by locating the first rectangular step at a distance of 2 feet 9 inches from and parallel to the partition opposite. Then lay off 6 feet from the step, dividing this line into eight equal parts. From the points marked, draw in the riser lines parallel to the first step drawn, or perpendicular to center line *ef*. Draw in the irregular line, which forms a break in this flight to allow a portion of the cellar stairway to be shown. As the risers of the cellar stairway are on the same plane as the upper stairway, the same lines will serve for both stairways. This will appear clearer when the second-story plan is drawn. Observe, however, that the width of the cellar stairway is reduced $1\frac{1}{4}$ inches, owing to the extra thickness of the brick partition in the cellar. Now draw the risers of the winding treads; find the larger width at the wall faces by the dividers applied to the scale on the engraving, and mark the points on the drawing. Next find the width of the door jamb by the same process, and mark the points on the drawing. Connect these points with those previously found, to

indicate the riser lines. The first riser will be immediately behind the door, and as there will be no nosing on this tread, the riser line will be in the position shown. The arrows indicate the direction towards which the stairs ascend.

Now locate the door and window openings in the exterior walls. Begin with the bay window. The front opening being 4 feet wide, take 2 feet on each side of the center line; mark these points on the face line of the wall. Next draw the window-frame lines, which indicate its thickness; the outer line of frame, being 4 inches in from the outer face line of the brickwork, forms on the jamb what is called the **reveal of the opening.** Mark this point and another point to indicate the thickness of the frame, which is 7 inches. Through these points draw two parallel lines. Now draw the reveal lines at each side of the opening. It will be observed that the window frame passes 3 inches into the wall beyond the reveal line; or, in other words, the width of the window frame is 6 inches wider than the daylight opening in the brickwork. Mark this 3 inches on each jamb and erect a perpendicular line extending to the full thickness of the brickwork. This will form a check in the jamb, which will allow the frames to be put in, after the brickwork is erected, if desired, or to be taken out and renewed when necessary. Now draw the jamb line of the window frame, which advances 2 inches from the brick reveal line on each side; divide the width of window frame into three equal parts and draw in two parallel lines between the jamb lines, as shown. The jambs of window frames are called **pulley stiles,** as the pulleys that the sash cords work over are located near the top of them. It will be observed that the furring and plastering space of 2 inches finishes against the frame forming the inner reveal, but, instead of the plastering, it is usual to insert wooden jamb linings, which assume the position of the plastering. Now draw the side openings of the bay window, locating them by the diagonal lines that are on the center lines of the openings, and fill in the window frames by the method explained in detail for the front window. Now locate the center lines of all the window openings in

the brick walls, from the lines and dimensions given on the plan, and draw the openings in the brickwork from these center lines; fill in the window frames and the inner reveals. In drawing the window openings, starting at the bay window, work towards the right and follow around the wall, finishing them in regular order before starting those in the other walls. It will be observed that the frames in the curved wall are curved on the plan, the lines being described from the center *s′*, and that the jamb lines of the frames are parallel to the radial line at the center of the opening; this makes an allowance for the insertion of the sash from the inside. If the jambs were made perpendicular to the tangent of the curve, that is, parallel with the brick reveals, the sash could be put in place only from the outside, and further, the frames could not be renewed without cutting out the brickwork. The dining-room windows opening on the veranda, marked *C. W.*, are shown with folding sash, opening inwards like the door openings. These are called **casement windows,** and extend down to the floor. After the window openings in the brick walls have been located and their frames drawn in, locate the stone window sills, which project 1¾ inches beyond the face of wall and extend 4 inches beyond the jamb line, so that they are 8 inches longer than the width of opening in the brickwork, the top of the sill between the jamb lines being worked to a sloping surface to shed the water. This is indicated by the miter lines at each jamb, these miter lines being the intersection of the sloping surfaces, or inclined planes. It will be observed that the sills of the bay window are resolved into a sill-course, which is continued around to the main wall. Now draw the door opening of the vestibule. Observe that the door frame passes into a check in the brickwork 1 inch beyond the reveal line, and that the frame is shown rabbeted, or checked, to receive the door. The door sill is in line with the water-table, which projects 1¼ inches beyond face line of wall, and at this projection is continued along the walls which are enclosed with verandas. Draw this line and the miter lines at the angles, as the projecting portion is cut to bevel off

1 inch, forming a slope, or *wash*, as it is called. Where the walls are not enclosed by the verandas the water-table projects 4 inches. Draw this line where shown, and miter lines at angles, since the upper surface is sloping. This will be better understood when the elevation and sections are projected.

Having completed the opening in the outer brick walls, proceed to draw in the window and door openings in the outer frame, or wooden, walls. Locate the center lines of the openings from the measurements given, and lay off the jamb lines, which will be one-half of the width of opening from the center line. Divide the width of the jamb, which is the thickness of the wall, into three equal parts, and through these two points draw lines parallel to the wall face. Form a groove in each jamb as shown, 2 inches deep, and draw another line parallel to each jamb 2 inches towards the center line of openings, and between these lines draw a line parallel to the face of wall. Now draw the line of sill, which is 1½ inches from the face line and extends 6 inches beyond each jamb. This is a conventional method of representing window openings in frame walls on plans drawn to this scale, as the minuteness of the actual parts cannot be clearly shown. Draw the outer door opening of the kitchen, which is shown in a manner similar to the other doorways, with the addition of the sill at floor.

The front and side verandas can now be drawn. First lay off the outer face line of the range of posts along the front, which is 8 feet from the outer face line of wall of library and parallel to line *m n*. Then draw the line perpendicular to it and 8 feet from the outer face line of wall, as shown, for the side range of posts. Now locate the center lines of the intermediate posts and the angles of the angular posts from the dimensions given, starting from the center line *a b*, and marking the points towards the right. To locate these points correctly, proceed as follows: Mark the point for first post, which is 4 feet 8½ inches from the center line *a b*, the center line of the second post being 3 feet 1¾ inches from the first. Adding the two distances together, we get 7 feet 10¼ inches,

the distance from center line $a\,b$. Measuring this distance from the center line $a\,b$, mark the point. This method is more accurate than working from point to point with the scale, and has the advantage that when the point is marked its accuracy can be checked by measuring with the scale the distances between the center lines of the posts. Having marked the points for center lines, erect perpendiculars to the outer face line of posts to define the center lines. As the intermediate posts are 7 inches square, draw a line for each range of posts $3\frac{1}{2}$ inches from and parallel to the outer face line of posts. At the intersections of this line with the center lines already drawn as centers, and with a radius of $3\frac{1}{2}$ inches, describe a circle for each intermediate post; tangent to these circles and parallel to the outer face line of posts, draw the line that will define the inner face line of posts. At right angles with this line draw the adjacent faces. As the rail of balustrade is of the same width as the posts, the outer and inner face lines will be continuous. Having finished the intermediate ones, draw the angular ones. Observe that the width of these posts, measured on the outer face line from the angle, is $4\frac{1}{2}$ inches. On each side of the angle mark this distance and draw the adjacent faces at right angles with the face line. Draw in the pilasters at junction with the frame wall, and let them project $1\frac{1}{4}$ inches from the face line of wall. Now draw the posts to the left of the center line $a\,b$, first laying off the angular one. Observe that there is a square return of 4 inches. Mark this point and draw the line connecting it with the angle of bay window. At right angles to this line mark a point 7 inches from it, and through this point draw a line parallel to the face line first found; this will define the inner face line for the angular and wall posts; complete them as shown, and draw in the intermediate one next to the center line $a\,b$. Divide the width of the baluster rail between posts into three equal parts, and through the points marked draw two lines parallel to the face line, which indicate the moldings, etc. on top of the rail; then draw the base lines around and projecting 1 inch from the posts, and mark in the miter

lines, as the edges are beveled. Observe that only a portion of the base can be seen, owing to the overlap of the baluster rail.

Now draw the line indicating the edge of the veranda floor, which projects 4 inches beyond outer face line of posts. Lay off this distance from the various face lines, and draw the line parallel to the face line of posts. Now draw the steps, as shown, the riser lines being parallel to the face line and the returns being at right angles therewith. Observe that the first step down at the entrance doorway cuts into the veranda floor, the riser line being on the center line of the posts adjacent, and the treads being 10 inches wide. Mark a point 2 feet 6 inches from first riser, and, drawing a line between these points and dividing the distance into three equal parts, draw in the lines. This will insure accurate plotting. Observe that the ends of the first step are in line with the base lines of posts. Draw the ends and return the other steps as shown. To draw the rear veranda and kitchen porch, follow the method just given, observing, however, that the posts are 6 inches square instead of 7 inches.

Draw the lines that indicate the door leading to the cellar, locating the points by scale measurements from the engraving, and also the dotted lines, which indicate the steps. The exterior work being completed, draw in the lines representing the kitchen range, boiler, sink, and drip board, and the position of the refrigerator and shelving in the pantry. The two circles enclosed in the angle of the partition indicate the position of the pipe lines to the bathroom overhead. Then draw the china-closet sink and hot closet in the butler's pantry. The china closet is shown with doors, and the line in front of it indicates the edge of the cabinet underneath. Draw the corner wash basin in the lavatory, as shown. Bisect the angle with a line, which will make an angle of 45°. On this line locate the center, describe the circle which indicates the basin, draw the surrounding line which indicates the basin slab, and also the parallel lines at the walls indicating the vertical slabs. Having finished these various fittings, proceed to locate and draw the registers, which are

placed over the hot-air ducts to the several apartments, where shown, first drawing in the center line and marking the outline to agree with the figured sizes, as 12 in.$\times$15 in., shown in library. These hot-air ducts constitute only a portion of the system of heating required for this building, the direct radiators not being shown in the plan, as their insertion does not affect the building construction, as does the hot-air duct system, for which provision must be made in the construction of the floors and partitions. Now draw the ducts leading to the second floor, which are located in the partitions, as shown. After the ducts are drawn, proceed to indicate the position of gas fixtures. Where they are located in the center of the rooms, draw diagonal lines from corner to corner, the intersection of which will be the center of the ceiling fixture. On this as a center, with a radius of 7 inches, describe a circle, dividing it into the number of parts required to designate the number of burners that will be on the fixture, which are indicated by the small circles. At the center of the fixture make a similar circle, and draw the lines radiating from the center to each burner. Observe that the center of the fixture in library is located on the center from which the curved wall is described.

Having completed the ceiling fixtures, locate and draw the wall fixtures where shown, the center being 5 inches from wall surface. Now locate and draw in the circles that are shown at intervals against the outer face line of walls and veranda and porch posts, which indicate the position of the rain-water conductors, it being essential to arrange their location on the plan with reference to the cornice projections, central position on wall surface, and other considerations that have to be reviewed in conjunction with the arrangement of the gutter outlets on the various sections of the main and veranda roofs, and is of further value in showing their connection with the drainage system, which is usually shown on the cellar plan. The pencil work now being finished, proceed to ink in the drawing, after which clean the sheet with soft rubber and remove the pencil lines that have overrun at the angles and openings. Draw in and ink the dimension

lines. Write in the dimensions. Ink the original center lines and letter them. Draw, ink in, and letter the line of the cutting plane *g h i j k l*, from which the longitudinal section will afterwards be developed, and letter the names of the various apartments and fixtures. Observe that variations in the size of letters and figures have been made in this plate from the standard sizes, to suit spaces, etc., which is to be followed by the student on his drawing. Take the size by the dividers and apply to the scale on the engraving, which will give the accurate size to put on the drawing. All the information relative to doors, windows, flues, ducts, etc. should be written in full on the drawing; but the reference letters at the angles of the building may be omitted.

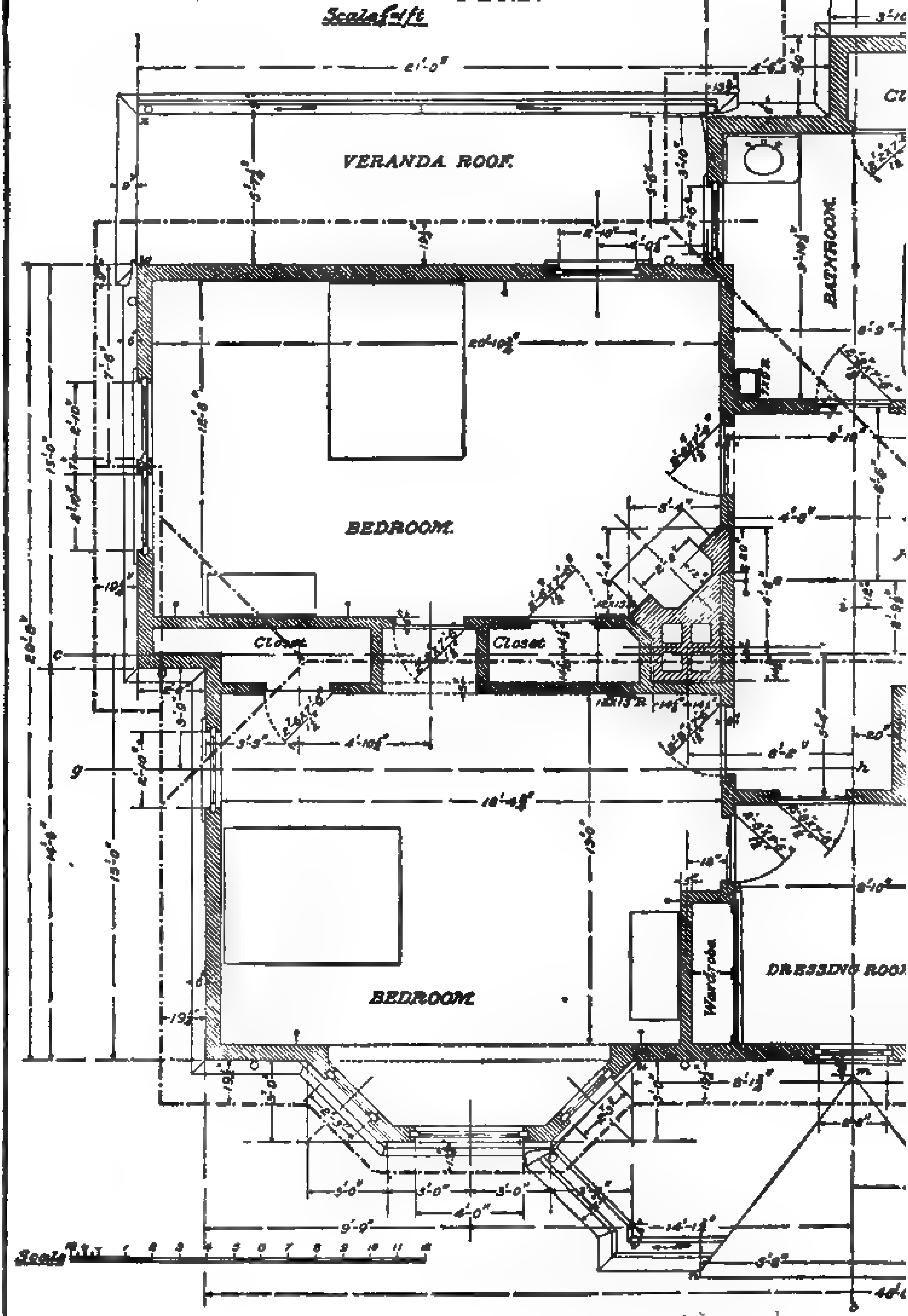
DRAWING PLATE, TITLE: SECOND-STORY PLAN

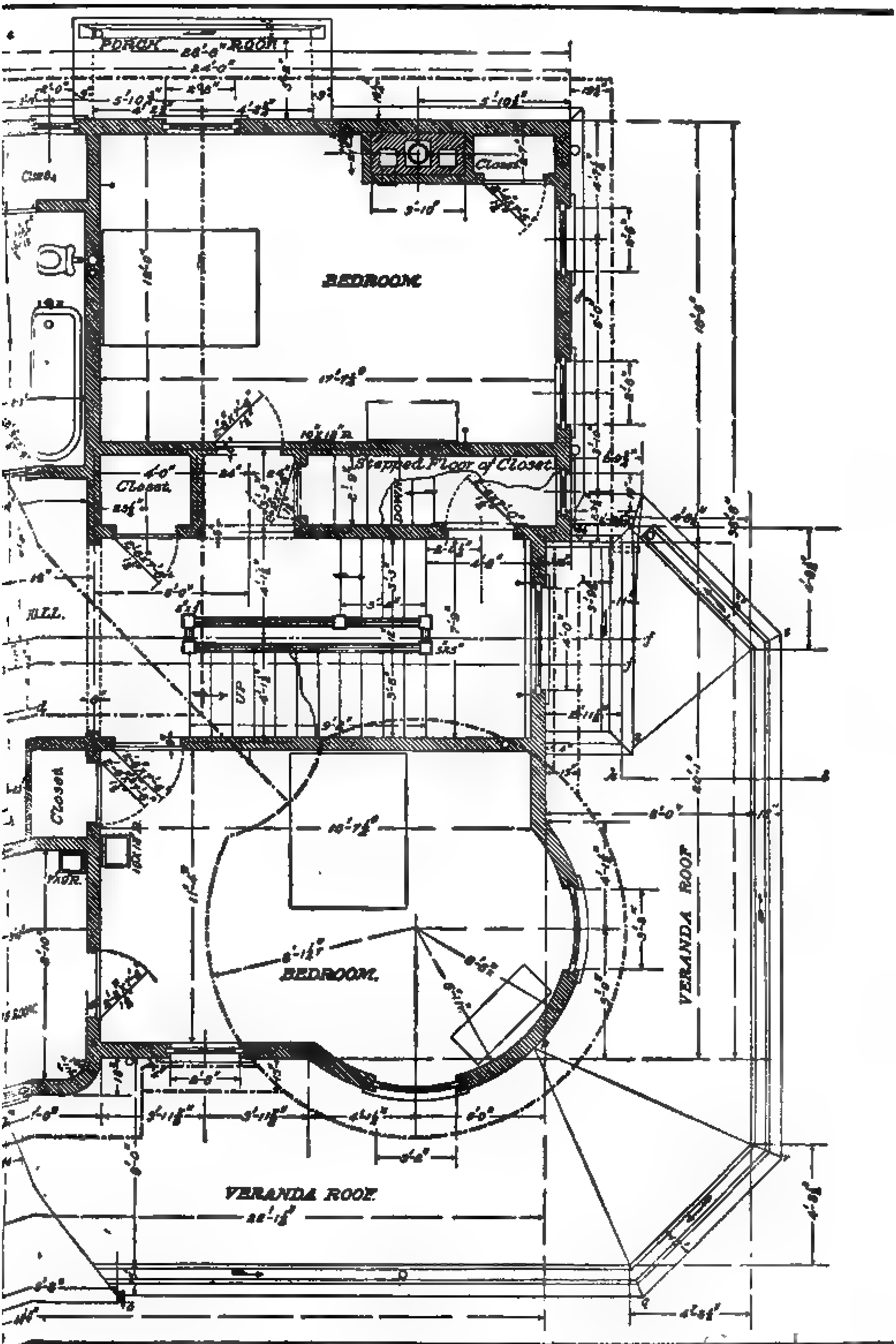
14. This plate shows the **second-story plan,** and is to be drawn to the same scale as the preceding plate, that is, $\frac{1}{4}$ inch = 1 foot.

Begin by drawing the center line *a b* at a distance of $7\frac{3}{4}$ inches from and parallel to the left-hand border line. Draw the center line *c d* at right angles to it and at a distance of $6\frac{1}{8}$ inches from the lower border line. Then draw the center line *e f* parallel to *c d* and at a distance, by scale, of 2 feet $9\frac{1}{2}$ inches. These center lines, as mentioned in the previous article, will constitute the base lines of measurement, from which the arrangement of the plan will be developed. Proceed by locating the angles on the outer face line of the building, which will define the outline of the plan in accordance with the instructions given for drawing the first-story plan. Then draw the thickness of the outer walls and locate the center lines of the partitions from the measurements given. Draw the partitions that will define the interior arrangement. It will be seen, by comparison of the second-story plan with the first-story plan, that many of the partitions occupy the same relative position as those underneath them, thus affording a continuous construction. Draw the

brick stacks, or chimneys, in which are located the open fireplace and the smoke and ventilating flues. The dotted lines connecting the left-hand flue with the wall surface of the room denote a terra-cotta inlet to the flue for the stovepipe connection, the line beyond the wall surface indicating the collar of the inlet. Draw the door openings in the partitions in accordance with the method followed on the first-story plan. Draw the ceiling beams, indicated by the dotted lines, spanning the recesses in partitions and forming the subdivision of the ceiling between hall and stair hall, and the ceiling beam at the bay window. Now draw the main stairway. Observe that the platform and landing newels are the same as those shown on first-story plan, but in this case the dimensions given to center line of newels, 4 feet 8 inches, is taken from the outer face line of timber wall. Draw this line; mark the distance from center line of newels to center of landing newel, 3 feet 4 inches, and the distance, 9 feet 3 inches, to center line of newels at the start of second stairway, which leads to attic. Draw in these lines, which also indicate the riser lines. Now draw the center line of the hand rail of each flight, locating it from the face line of partition walls, by the measurements given, and draw parallel to center line *ef*. At the intersection of these center lines with the riser lines, which gives the center of the newels, describe circles 5 inches in diameter, and then circumscribe squares, which will denote the newel posts; divide the distance between center lines of newels into the number of spaces shown for each flight, and draw in the lines at right angles to center line *ef*, which will indicate the treads of the stairway, and which are 10 inches wide between the riser lines; correctly stated, the lines shown represent the face line of risers, while the distance between these lines gives the width of tread, exclusive of the nosing, or projecting section of the tread beyond the riser. As the riser lines of the second stairway are immediately over those of first flight, they occupy the same relative position on the plan, the irregular line indicating the break in second stairway, so that the lower one can be seen. Now draw the lines

SECOND STORY PLAN.




PORCH ROOF
BEDROOM
Closet
Stepped Floor of Closet
Closet
HALL
UP
DOWN
Closet
BEDROOM.
VERANDA ROOF
VERANDA ROOF

showing the width of the hand rails, which is 4 inches; measuring from the center line will give 2 inches on each side.

After the hand rails, draw the base lines around the newels, observing that only portions of the base can be seen, as the hand rail, occupying a higher plane, overlaps it. Draw the arrows, which indicate the direction followed by the flight. Having completed this stairway, draw the section of stairway to kitchen, which is exposed by breaking off the closet floor, as shown. Locate the first riser, which is 5 feet 5¼ inches from outer face of wall, as shown on first-story plan. Make the width of treads the same as shown on first-story plan. Observe that there is a riser line shown at the door opening on the platform of main stairway, which indicates that the platform is higher than the landing of kitchen stairway. This can be verified by counting the number of risers in each stairway up to the platform level.

Now locate and draw the window openings in the exterior walls, first locating the center lines and drawing the jamb lines, etc. by the method given for those on the first-story plan. Notice that the window sill is continued as a table course around the bay window, supported by a bed mold and facia, which will be shown on the elevation in a subsequent plate. In wood construction the sills are either worked with a sloping upper surface, to shed the water, or the sill canted for that purpose, so that there are no wash miters to show on plan, such as there are in stone construction.

After the window openings are completed, proceed to draw the veranda and porch roof. Beginning with the front and side verandas, first locate and draw the outer face line of the beam, which is supported by the posts, and is 8 feet from and parallel to the straight-line wall surfaces. This line having been drawn, locate the angles where the line changes direction, from the measurements given. Reference to the first-story plan will give the student a better understanding of the position of this line, as this forms the base line from which subsequent measurements are taken. Parallel to this line, and at a distance of 15 inches therefrom, draw the line

of the eave, or horizontal cornice projection. Next draw the pediment, or low-pitched roof, over the front-entrance section of the veranda. Observe that the center line of the ridge is on the center line *a b*. On each side of the ridge lay off the distance shown of 5 feet 8 inches, which will give the point of intersection of the valley of the pediment roof with the eave line of veranda. On the center line *a b*, at a distance of 6½ inches from the face line of wall, mark a point. From this point draw the lines of the valleys *m n*, *m o* on each side of the center line *a b* to the point on the eave line already found. A **valley** is the line of intersection of the inclined surfaces of two roofs, the eave lines of which form an interior angle. Draw the cornice projection of the pediment, which advances 3 inches in front of, and is parallel to, the eave line already drawn. From the point of intersection of each of the valleys with this eave line, and at right angles thereto, draw the eave lines of the pediment.

Now draw the center lines of the parapet walls of the balcony, which surround he stair-hall window. As shown, the center line of the front wall is 2 feet 11½ inches from the outer face line of wall of building, and is parallel to it. The center lines of the return, or end, walls are each 4 feet ½ inch from the center line *e f* of the window. The width of the coping being 11 inches, lay off 5½ inches on each side of these center lines, and draw the edges of the coping. The second line from the edge of the coping of front wall on the inside indicates the width of the balcony gutter. The dotted lines that cross the wall at the end indicate the weeper, or gutter outlet. The curved line in advance of the parapet line represents the intersection of the curved section of the parapet wall with the inclined surface of the veranda roof. The line from the angle at eave line to angle of coping shows the miter line of the curved surfaces of the front and return wall. Now draw the lines denoting the gutter which is constructed in the cornice. Observe that the inner line is on the beam line, over face of posts already described. The width of the gutter from this line is 9 inches, which space is further reduced 2 inches on each side by the lines indicating

the junction of the sloping sides of the gutter with the bottom, or bed. These lines on the plan are shown parallel with the edges of the gutter, which is the usual course followed on a small scale drawing; but in practice or on a larger scale-detail drawing, these lines will converge towards the gutter outlets, owing to the grade, or pitch, of the bed of gutter. The circles in the gutter show these gutter outlets, and the arrows indicate the descending grade towards them.

Locate and draw the hip lines *pq*, *pr*, *st*, and *uv* of the veranda roof. A **hip** is similar to a valley in the respect that it is the line of intersection of the inclined surfaces of two roofs, but with the difference that the eave lines form an exterior angle; in other words, they represent a miter line that is formed by the change in direction of the roof, or inclined plane, and this miter line is resolved into a hip or valley, according to the nature of the angle at the eave lines.

Observe that the hip, or miter lines, are not drawn across the bed of the gutter, since it is a flat surface, miters only being shown where an angle is formed. The bed of the gutter at line *pr* is thus shown, as the grade, or pitch, changes at this point.

Now draw the rear veranda roof in accordance with the method given above, first drawing the beam line, which is 5 feet 7½ inches from the wall face. The cornice projection from this line is only 9 inches, the cornice at the open end being horizontal, and the line *wx*, following the slope of the roof, forms a half pediment over the cornice. Next draw the porch roof. As here shown, the roof plane is unbroken, except where the gutter is inserted, and is a simple slope from the eave to the wall junction. Circumscribing the wall of the building, where not occupied by verandas and porch, is a line 6 inches from the wall. Draw this line, which shows the projection of a molded course around the building, formed by the corona, or table, of the veranda cornice; miter the angular connections, and carefully observe and draw the connections with the cornices. These connections will be better understood when the elevation and

subsequent plates are drawn. The exterior work being finished, draw the fixtures in the bathroom, consisting of the plunge bath, foot-bath, water closet, and wash basin, first locating the center lines by the application of the dividers to the scale on the engraving, which will give their position on the drawing. The various sizes can be found in the same manner, from which their complete outline can be drawn. The soil and ventilating pipes, which are continued up to and through the roof, are enclosed in the partition wall, which in this case is increased to 7 inches for that purpose.

The circle in the partition adjacent to the stair platform indicates the ventilating pipe from lavatory. Draw the enclosing frame and doors of the wardrobe in the dressing room. The line that advances from the line of frame indicates the shelf, under which a range of drawers is placed. Draw the outlines of the bedsteads and bureaus in the bedrooms, which, in plan making, materially influence the location of the window openings and gas fixtures.

Locate and draw the registers of the hot-air ducts from the positions shown on plan. In the closet adjacent to the four-flue brick stack, a section of the floor is elevated so that branches can be taken from the vertical duct to the wall registers in rooms. Locate the gas fixtures, and indicate in the same manner as shown on the engraving. Draw in the circles that denote the position of the rain-water conductors. The two on the front wall discharge on the roof of the veranda, as also the one adjacent to the rear veranda. The others continue down to the ground line.

The heavy broken and dotted lines indicate the constructive lines of the main roof planes, and will be considered later on.

The pencil work being finished, proceed to ink in the drawing, after carefully cleaning same. Draw in and ink the dimension lines and write in the dimensions, and draw, ink in, and letter the line of the cutting plane *g h i j k l*. Letter the names of the various apartments and fixtures, as shown on engraving, and letter the center lines, making the drawing conform with the engraving in all respects, except that the reference letters may be omitted.

Now proceed to draw the constructive lines of the main roof. Begin by drawing the ridge lines. The ridge line parallel to center line *c d* is midway between the front and rear walls of building, and is therefore 14 feet 0 inches from the outer face line of either wall. The ridge line parallel to *a b* is midway between the walls of the rear extension, or wing, and is therefore 14 feet 3 inches from the outer face line of either wall. Now draw the cornice projection lines around the building, which are parallel to the face line of walls, and in general are 18 inches from it, except at the bay window, where the distance is 13¼ inches; adjacent to the tower two eave lines are shown, which indicate a higher and lower plane, which will be fully understood when the elevation is drawn on a subsequent plate. From the center of the tower, with a radius of 8 feet 1¼ inches, describe the circle denoting the eave line of tower. The segment advancing into this circle denotes the intersection with the adjacent roof planes; the center for describing the segment is at the intersection of the ridges.

As the eave lines over the rear veranda roof form an interior angle, the line connecting their intersection with the ridge line will be a valley. While this line from the ridge, if continued to the intersection of the straight walls, would meet an exterior angle, and is therefore a hip, the limit of its length in this case is the wall of the tower. The projection of the cornice over the bedroom wing to the left of center line *a b* indicates a gable cornice, a **gable** being the triangular-shaped wall on the front or side of a building, under the inclined lines of the roof planes. The ridge is shown in the center, and is the intersection of the roof planes that meet on this line. Observe that the main roof gable adjacent to the wing gable just described is **truncated**; that is, a portion of it from the ridge line is cut off to a line parallel with a horizontal line connecting the eaves. The dimensions of the plane formed by cutting off this section can be found on the plan to be 3 feet 9 inches from the wall face to ridge intersection, and the distance from the ridge to the eave intersections 5 feet 4¼ inches. The latter

points having been found, connect them with the intersection on the ridge, thus defining the hip lines of the truncated part of the roof. Ink in the roof lines with heavy broken and dotted lines, as shown on the engraving. The point of intersection of the various roof planes will be required in developing the elevation and longitudinal section, and many advantages are obtained by locating the main roof lines on a plan, as an intelligent conception can thus be formed of the requirements of the plan of the building; roofing considerations, in a well-studied plan, very often require its modification to secure a satisfactory design.

DRAWING PLATE, TITLE: CONSTRUCTIVE DETAILS

15. This plate comprises a number of figures, which are the **details** relative to the construction of various sections of the suburban residence. They are to be drawn to a scale of $\frac{3}{4}$ inch = 1 foot. Figs. 1, 2, 3, and 4 are drawings showing the construction of the second-story bay window, and the balustrade that surmounts it. Fig. 5 shows the construction of the corona and bed mold forming the molded course that circumscribes the building, as shown on the second-story plan, and also shows the construction of the window frame and inside trim, or casing, the plaster cornice of the first-story ceiling, etc. Fig. 6 shows the construction of the main cornice of the building, the plaster cornice of the second-story ceiling, etc. Figs. 7 and 8 are, respectively, a sectional elevation and a vertical section of the front veranda.

In developing Figs. 1, 2, 3, and 4, which pertain to the bay window, the several portions of each require to be drawn in successive order, so as to obtain their relative position in each figure. Begin by drawing the center line $m n$ $5\frac{5}{8}$ inches from and parallel to the left-hand border line; at a distance of $3\frac{5}{8}$ inches from and parallel to the center line $m n$, draw the center line $o p$, after which proceed to draw Fig. 3, which is a one-half plan of the second-story bay window as seen

from below. This view is taken for the purpose of showing the position of the various members of the cornice, including the dentil course, from which projections will be made in developing Fig. 2.

Commence on Fig. 3 by drawing the outer face line of frame wall $q\,r$ at a distance of $\frac{27}{32}$ inch from, and parallel to, the lower border line. At a distance of 3 feet, by scale, lay off the face, or sheathing line, of front of the window parallel to $q\,r$. On this line lay off a distance of 3 feet from center line $m\,n$, and at a farther distance of 3 feet from this point, draw a line parallel to $m\,n$, intersecting $q\,r$. Connect this point to the point on face line of the window, and the face line of the side window will be defined. Parallel to the front and side lines now located, and at a distance of 7 inches therefrom, draw the lines indicating the width of the window frames. Observe that this width coincides with the face line of the plaster, and is therefore the full thickness of the frame wall from the outside of the sheathing to the inner face of the wall. Now draw the jamb lines of the window frames. The jamb of the front window is 24 inches from, and parallel to, line $m\,n$, which will leave a distance of 12 inches, the width of the angle pier on the face line. From the angle, mark a point 12 inches on the side line of the window, and draw the jamb line through this point at right angles to the side line (thus making the side width of pier the same as the front). Then draw the opposite jamb line 2 feet 3 inches from the one just drawn. These jamb lines and others parallel thereto can be drawn by using the 45° triangle on the edge of the T square, as the side line of the window will be found to make an angle of 45° with the face line of wall $q\,r$. Now draw the construction of the window frames as follows: Begin with the frame of the front window. Draw the thickness of the jamb, which is $1\frac{1}{4}$ inches; the 7-inch width is then divided as follows: 1 inch for outer lining of window frame, 2 inches for upper sash, $\frac{1}{2}$ inch for the parting strip between sash, 2 inches for lower sash, the remaining space being occupied by the sash-stop bead, which keeps the lower sash in position. The plaster casing of the window frame is 1 inch

thick, which thickness is taken up by lath and plaster. Observe that the edge of the outer lining projects ½ inch in front of the jamb line; that the parting strip is inserted into a groove in the jamb ⅜ inch deep; that the strip projects ½ inch from the jamb; and that the sash-stop bead is ½ inch thick; so that these three edges are in line with one another and parallel to the jamb. Now draw the width of the sash stile. This width is 2 inches to the glass line, or rabbet, in which the glass is bedded. The rabbet is ⅝ inch wide, which makes the total width of sash stile 2⅝ inches. The inner edge of the sash is molded. The rabbet for the glass is on the outside, so as to make it water-tight, which is secured by bedding the glass in oil putty and forming a beveled fillet of putty on the outside, which sheds the water. Now form a box for the sash weights to work in, behind the jamb, by setting the first stud, or upright post, in the wall framing, 2½ inches back of the jamb. Draw the outside casing, which is 1¼ inches thick and 4½ inches wide, the angular casing being of the same width. Next draw the inside casing, or trim, which is composed of a facia, or plate, ⅞ inch thick and 4⅝ inches wide, against the back edge of which is attached what is called a **back band** ⅞ inch thick and 1¼ inches wide, and in the angle formed is attached a molding ⅞ inch thick and 1¾ inches wide. On the face edge of facia a ¼-inch bead is indicated. Having finished this jamb section of the window frame, draw in those of the side window in the same manner, after which draw the angle post, which is composed of several sections of scantling, or small timbers, so arranged as to break joint and form a solid interior and exterior angle. The angle at junction with wall surface is made secure by a piece of scantling of a triangular section nailed to the wall sheathing. The outer casing at this angle is mitered on the edge against which the ends of the beveled siding or finished wall surface abuts, which will secure the siding in position.

From what has been already stated in connection with this plan, the student will realize that a detail drawing must show *every part in detail*, the various items of construction being duly considered. Each part of the detail must be drawn in

the actual position it will occupy in the finished structure. Drawn to the scale of $\frac{3}{4}$ inch = 1 foot, it therefore represents $\frac{1}{16}$ the actual size.

Now draw the thickness of the main wall 7 inches from, and parallel to, qr; show the thickness of the sheathing 1 inch and of the lath and plaster 1 inch. At a distance of 4 feet $10\frac{1}{2}$ inches from the line mn draw the jamb line of casing, and finish the wall casings, as shown. The angle post is composed of three thicknesses of 2" × 5" scantling, on which is attached the plaster ground, with the edge beveled inwards, which tends to bind the edge of the plastering and keep it from springing when the casings are nailed in place. As previously mentioned, this figure is a view from below, so that the head-jambs, head-casings, lintels, and top rails of the sash are seen in full. Therefore, the lines connecting the various sections should be drawn in; they will denote the position of the parts when in place.

Having advanced thus far with Fig. 3, next proceed with Fig. 4, which is a section of the upper portion of the bay window on line mn. Draw the second-story floor line, which is 8 feet $10\frac{1}{2}$ inches by scale from, and parallel to, the lower border line. Draw, 2 feet 6 inches below the floor line, the line of the head-jamb of the window frame. At a distance of 3 feet $3\frac{1}{2}$ inches from the center line op, draw the front face line of the bay window, which is also the line of the window frame. Lay off the width of the window frame 7 inches and draw the head, sash, and inside casing, and the section of the wall that is above the head. The sectioned ends denote the horizontal framing in position. Draw the section of the main wall, which is above the head of casing, and which finishes the opening in the wall behind the bay window, the center line op being in the center of this wall. Observe that there is a section of a beam composed of two thicknesses, spanning the wall opening, which is cased up similar to the inside casing on windows, but instead of the square edge it is finished with a quarter round. This beam supports the wall construction overhead, the studs of which are shown to run down and rest upon it. The beam

is 4 inches in thickness, and it will be noticed that the studs are reduced to this width, and that the vertical strips $\frac{1}{4}$ inch thick are continued down each face of beam, thus securing a rivet for the plaster work from the floor level down. Draw the horizontal lines from the dimensions given. The thickness of the floor is $\frac{7}{8}$ inch; the depth of joist, or floorbeam, 10 inches; the plaster cornice, including the regular thickness for lath-and-plaster ceiling, $7\frac{1}{2}$ inches; the intervening wall surface between *cornice* and *casing*, $6\frac{1}{8}$ inches; and the width of casing, $5\frac{1}{2}$ inches.

Draw in the coves of the cornice with the compasses, scale the members with the dividers, and draw in the moldings, guided by the eye, their projections from the surfaces first being found from the engraving. In order to represent the jamb lines and casings of the side window on this figure, it is necessary to project all these lines forward to the plane represented by the line *m n*, as has been done with the jamb lines adjacent to the main wall, which, transferred to a horizontal line under the figure and projected upwards and intersecting with their respective members, drawn horizontally, will define the jamb lines and casings in their proper position when viewed through the plane on line *m n*. The process of transferring these points is readily done by marking them on the edge of a strip of drawing paper placed on the line *m n*. Marking carefully the position of the main wall, the strip can then be applied on the horizontal line under Fig. 4, first making the wall lines of Fig. 3 coincide with those of Fig. 4 and then marking off the points. This is more expeditious than transferring each space with the dividers, but it requires precise work to secure good results.

Now draw the frieze, the casing of which is $1\frac{1}{2}$ inches thick. At a distance of 12 inches from face of the frieze draw the cornice projection, after which draw a line 2 feet $3\frac{1}{2}$ inches from head-jamb, which will define the top of the crowning member of the cornice. Then lay off the subdivisions of the entablature from the head-jamb line, $3\frac{1}{2}$ inches for the facia of architrave, 2 inches for the astragal mold of same, $9\frac{1}{2}$ inches for the frieze, 6 inches to the drip edge of the

corona, and 6½ inches for the corona and covering member. Observe that the soffit, or lower face of the corona, is ½ inch higher than the drip edge, which gives a space of 6½ inches for bed molds and dentils. In drawing the moldings and other members, first draw a series of horizontal lines between the main divisions already located, which will define the thickness of the various members. Then draw a series of vertical lines parallel to the center line *o p*, and measure the projection of each member with the dividers from the face of the frieze. Having fixed these points, the moldings of the cornice and the bead of the astragal can be drawn with compasses. After the outline is correctly drawn, mark the thickness of the material of which the members are constructed, and their widths, and finish the section of the **entablature**, which is the term given to the assemblage of the parts separately known as the *architrave*, or beam, immediately over the window or door openings; the *frieze*, or upper beam, corresponding in position with the roof construction; and the *cornice*, or projecting table, at the top of a wall, which represents the finish of the roof covering.

Now draw the floor of the balcony over the bay window, the pitch being formed by beveled strips nailed to the floor joists. Form the gutter in the cornice, as shown, and the sill and frame of the door that opens on the balcony.

Draw the thickness of post and the section of balustrade, the center line of which is the face line of the wall sheathing over the window head. Draw this line and draw the horizontal lines that define the base, baluster, and cap rail. Draw the base and cap rail, after which lay off the blocks of the baluster, and the members of the turned section of baluster, by a series of horizontal lines, and draw the curved outline with the bow-pencil, after first carefully locating the position of the centers by vertical and horizontal lines. The height of the post cap cannot be determined until the **ramp**, or upright curve, on the cap rail is drawn.

Now draw Fig. 2, which is a one-half elevation of the upper portion of the bay window, with the balustrade which surmounts it. This is done by projecting vertically those

lines of Fig. 3 which can be seen from the outside of the building (this being an outside elevation); they represent the edges of the outer lining of the window frame, the outside casings, the angle lines, and the sash lines. Now project, from Fig. 4, the entablature lines, the edge of outer lining of the window frame, and the sash lines; the intersection of these with the vertical lines drawn from Fig. 3 will define the head of the window frame, the sashes, and the panelings of the outside casings. Before the miters of the moldings, and the intersection of the cornice lines and the dentils can be located, the horizontal projection of the cornice must be drawn on Fig. 3. From Fig. 4 transfer the horizontal projection of the various members from the frieze line, with the dividers or by means of a strip of paper as before mentioned. Mark these points on the center line *m n*; draw the line of extreme projection first, which will be found to be 12 inches from the frieze; now, at right angles to the frieze of the side window, 12 inches from and parallel thereto, draw the side-cornice line of extreme projection; from the intersection of these lines to the angle of the outside casing draw the miter line. All the points of the cornice members can now be projected from the center line *m n*, forward to this miter line; and, by the use of the 45° triangle on the T square, these lines can be continued across the side window. The angle of intersection of the outer lining of the frame with the face line of the main wall, a reentering angle of 135°, should be bisected according to the method explained in Art. **31**, *Geometrical Drawing;* the line of bisection will be the miter for the bed molds, which continue along the main wall. Observe that the projection of the main cornice is greater than that of the bay window, and is 19½ inches from the face line of the wall. Bisect the angle at the intersection of this line with that of the side window; the line of bisection will be the miter for the crowning members of the cornice. Now lay off the dentils, which measure 2½ inches on the face. Begin on the face line of the dentil course at the center line *m n*, and mark one-half the width, which is 1¼ inches; then, at the angle, mark a full dentil. Mark a

point in the center of the width of this dentil, and divide the length of the line between this point and the center line *m n* into ten equal parts, as explained in Art. **31,** *Geometrical Drawing*, which will give the center of each dentil. With the dividers set to 1¼ inches, mark the points on each side of center, thus obtaining the width and position of each dentil; draw the line that denotes the depth of the channel between them, which is 1¼ inches, and complete the dentils. To locate the dentils on the side window, first mark one-half the width of dentil from each angle and divide the remainder of the line into thirteen equal parts, and proceed as before. Having finished the dentils, project vertical lines from the plan to the elevation, Fig. 2, their position on the elevation being the same as would be seen on the plane perpendicular to the line *m n*. The intersections of the cornice molds, etc. can also be projected, and the cornice and molds completed on Fig. 2.

Before the balustrade can be drawn in Fig. 2, it will be necessary to draw Fig. 1, which is a plan of the balcony over the bay window as seen from above. Begin by drawing the face line of the attic wall, at a distance of ¾ inch from the upper border line, and perpendicular to the line *m n*.

Then draw the center line of the balustrade 3 feet from, and parallel to, the attic wall. On this line lay off the angular point 3 feet from the center line *m n*. Mark the distance of return of the attic wall from the center line *m n*, which is 6 feet. Join this point to the angular point on the center line of the front cap rail, by a line that will define the center line of the side rail. Draw the edges of the cap rails at a distance of 2½ inches from the center line. Observe that the rails are of the same width as the angle post. Now draw this post, the size on the face lines being 4½ inches on each side of the angle, and the returns at right angles with the rails. Then draw the post at junction with the attic wall, the angle being 3½ inches from it, and the width on the face line of the side being 4½ inches, the return being at right angles with the rail. From the intersection of this return with the inner line of the rail, draw a line at right angles

with the attic wall. Now indicate the position of the balusters under the side rail in dotted lines, as shown. As the balusters are 3 inches square, draw the face lines 1½ inches on each side from the center line of the rail; lay off 1½ inches, which is one-half the thickness of the baluster on each post, and divide this line, which is thus 3 inches longer than the space between posts, into eight equal parts, which will locate the center of each baluster. With the dividers set to 1½ inches, lay off from each center the position of the individual balusters and draw them, the edges being perpendicular to the center line.

Next draw the balustrade of Fig. 2, beginning by projecting the lines of the posts down from Fig. 1. This done, proceed to draw the balustrade on the front of window. Project the lines of the rail and the base from Fig. 4. To draw the ramp of the rail, locate the center of the curve at a distance of 9 inches from the post, and at a distance of 4 inches above the upper edge of the rail. From this center, with a radius of 4 inches, describe the vertical curve of the upper face of the rail; with a radius of 8 inches, describe the curve of the lower face of the rail. Draw a horizontal line from the center, from which the curves are described forward to the post, from which measure down 4 inches, the thickness of the rail, and draw the lower line of the rail. At the intersection of this line with the curve, draw the miter line. Now draw the curved lines defining the members from the horizontal line up to this miter, and from their intersections continue them forward to the post.

Careful observation will show that, as this miter line does not bisect the angle of 90° formed between the upper horizontal line of rail and the tangent line to the curve, it is not a true miter, and that the short section of horizontal rail against the post will vary slightly in outline from that of the other rail; but, as the ramps are worked out of a solid block, the molding is developed to suit the shape at the miter line.

Now draw the rail over the side window, the ramps of which, being projected on a plane that is turned at an angle of 45° from the face line of side window, present a complex

appearance. First draw the horizontal lines of the rail; the main lines of the ramps can be drawn approximately as follows: Project the joint line *1–1'* and the miter line *2–2'*, from Fig. 2, to *1''–1'''* and *2''–2'''–2*^{IV}, in Fig. 1. Transfer these lines to each end of the side rail, which will define these joint and miter lines in the position they occupy on the side rail. Now project the joint lines *3–3'–3''* and *4–4'–4''*, and the miter lines *5–5'–5''* and *6–6'–6''*, from Fig. 1 down to Fig. 2. The intersection of the line from point *5* with the horizontal relative line on Fig. 2 will give the point where the curve begins, and the line from point *3* will give the point where the curve joins the straight line. The lines from points *5'* and *3'* on the center line of the rail will give the points on the center line of the rail in Fig. 2, where the curve begins and ends; similarly, the lines from *5''* and *3''* will give the beginning and the end of the curve on the inner edge of the rail. Join the points with an irregular curve, drawing in the lower curve and the intervening members. Locate the ramp next to the angular post in a similar manner. The cap rails being now drawn, finish the caps and bases of the posts and draw in the balusters; begin with those over the front window, lay off 1½ inches (which is one-half of the thickness of the baluster) on the post at the base rail, and divide the line between this point and the center line *m n* into seven equal parts; the divisional points will be the center of the balusters; with the dividers set to 1½ inches, mark the edges from these centers and draw the vertical lines. Now draw the horizontal lines by projecting them from Fig. 4, and complete the balusters. Draw the balusters over the side window, first drawing the center lines by projecting them from the center of the balusters indicated under the side rail on Fig. 1. Then draw the horizontal lines defining the height of the blocks at top and bottom of the baluster. This done, project the angles of the blocks down from Fig. 1, which gives them the appearance of lapping over one another. Observe, also, that the blocks measure less in width on the face, this being caused by the fact that the face of the object represented is not parallel to the plane on which it is drawn,

this diminution being proportionate to the angle that the object makes with the plane to which it is projected. This applies, however, only to angular objects, or those not circular on the plan. The baluster sections, which are turned, are circular on the plan, and, therefore, do not change in appearance. Having already drawn the center lines for them, draw the horizontal lines across for the molded portions; locate the centers from which the curves are drawn, and complete the balustrade. Observe that the eave mold abuts against the wall post. The height of these lines above the cornice can be obtained from Fig. 6. The intersection can be projected from Fig. 1, but not until the cornice lines have been drawn in position. Proceed to lay down the cornice lines on Fig. 1. From the center line of the rail lay off the cornice projection, which is 13¼ inches from, and parallel to, it. The side cornice is also 13¼ inches from, and parallel to, the center line of the side rail, and the main cornice is 19¼ inches from the line of the attic wall. This line being drawn, draw a line 4 inches from, and parallel to, it, which defines the crown slope of the cornice, which is shown on Fig. 4. The line adjacent to this one is the intersection of the slope of the side of the gutter with the bed. As the sides of the gutter are sloped, the width of the bed, or bottom of the gutter, diminishes, as was explained relative to the gutters on veranda roofs. Locate this line by the dividers applied to scale.

By reference to Fig. 6, which is a section of the main cornice at the eave, it will be seen that the molding that overhangs the gutter projects 6 inches beyond the face line of the wall. On Fig. 1, at a distance of 6 inches from the attic wall (which is on the same line as the face line of the main wall), draw the line of this eave mold, which will intersect with the line of post. This intersection being found, it can be projected down to Fig. 2. The slope line above this intersection on Fig. 2 shows the intersection of the inclined plane of the roof with the face of the post. Now complete Fig. 1. Draw the lines that represent the molded caps; also, draw the line in advance of the rail that shows the edge of

the gutter. The line in advance of the eave mold is the intersection of the slope of the side of gutter with the bed. Draw the miter lines and the hip line shown, which is the junction of the inclined surfaces of the balcony floor. The post in Fig. 4 can now be completed by projections from the post on Fig. 2. Figs. 1, 2, 3, and 4 should now be carefully examined and compared with the engraving, errors corrected, and omissions filled in.

Now draw Fig. 5, which is a transverse section through the head of the first-story bay window, to show the construction of the molded course, the sill on which the frame wall of the second story is erected, the head of the window frame, etc.

Begin by drawing the face line of the wall, projecting down from Fig. 4, as it occupies the same plane. At a distance of 12 inches from the face line, draw the inner line of the brick wall, from which draw the furring and plastering lines, each 1 inch apart, total 14 inches, as shown. Show the stone lintel on the outside, 7 inches thick, the balance being occupied by the brick arch; lay off the thickness of the frame wall, which is 7 inches, 1 inch of which is for the wall sheathing, 5 inches for the stud, and 1 inch for the lath and plaster; draw the top line of stone lintel and brickwork at a distance of $1\frac{11}{16}$ inches from the lower border line and at right angles with the face line of wall; mark the depth of stone lintel 10 inches, and form the reveal 4 inches deep from face line. Observe that the stone at this depth is checked 1 inch deep, to allow the outer lining of window frame to pass up behind it; this forms a **weather check,** as it is called. The soffit, or bottom of the brick relieving arch, behind the stone lintel, is shown with a rise of 1 inch above the springing line at jamb. At a distance of 2 inches below the bed of the lintel, draw the line of head-jamb; the sizes of the parts of the frame are the same as those given for the window frames already drawn. The space between the inner face of window frame and face of plaster is occupied by what is called a **jamb lining,** which is $\frac{1}{2}$ inch above the line of head-jamb. Now draw the inside casing, or trim, which, in this case, has

a cornice supported by molded brackets; draw the sill on top of the brick wall, and show a $\frac{1}{4}$-inch joint for the mortar bed; draw the molded course, as shown, which projects 6 inches from face of wall. Mark the point where the curved sheathing starts from the straight line, which is $17\frac{3}{4}$ inches above the crown of fillet. Connect these points by an irregular curve. It would be well, however, to mark a point in the center of curve, to insure accuracy. To do this, mark a point on the wall line 9 inches below the highest point of curve, and from this point draw a line at right angles to wall, and find the distance to its intersection with the curve; lay off this distance on the drawing, and mark the point. A line used in this connection is called an *ordinate*, and is of great value in locating any number of points on a curve. At a distance of 3 feet $\frac{1}{8}$ inch above the line of jamb lining, lay off the line of second-floor level and subdivide this distance, as shown, $1\frac{3}{4}$ inches for two thicknesses of floor (the rough one and the finished one), 10 inches for floor joist, $6\frac{1}{8}$ inches for plastering and plaster cornice, and $8\frac{7}{8}$ inches for the wall frieze. Observe that the cornice of trim is carried across the wall, occupies the position of an architrave, and is utilized as a picture molding. Draw in these lines and the moldings and dentils of the cornice. Observe that there is a nailing strip on the lower edge of the joist, to which the furring strip is attached, and that the joist is shown spiked to the stud, and is further supported by a vertical block extending from the under edge down to the sill, which is also spiked to stud.

After completing this figure, proceed to draw Fig. 6, which is a transverse section of the main cornice, etc.; from the center line of the wall *op*, draw the thickness of the main wall, showing the thickness of the sheathing, and of the lath and plaster. Draw the top line of the wall plate at right angles to center line *op*, and at a distance of $1\frac{5}{8}$ inches from the upper border line; the wall plate is constructed with two thicknesses of 2″ × 5″ scantling; at a distance of 2 feet $9\frac{1}{4}$ inches from top of wall plate, draw the edge of frieze and its thickness, $1\frac{1}{4}$ inches; from the edge lay off the width of

frieze, 9½ inches, 6 inches to drip of corona, 6½ inches for the corona and covering member, and 3 inches for the slope of the crown. Draw these horizontal lines, and subdivide them for the molded members. Observe that the molds are identical with those drawn in Fig. 4 for cornice of the bay window, which is practically the main cornice with reduced projection. Mark the line of projection 18 inches from face of frieze; at the intersection of this line with the line drawn for the top of covering member of cornice, draw the pitch or slope line of roof. This pitch is given as 10 inches in 1 foot, which means that for each foot of horizontal distance the vertical height will be 10 inches. Draw a horizontal line from top of covering member of cornice, say 3 feet long by scale; the vertical height will then be 30 inches, or 2 feet 6 inches. Draw this line, connect its upper point with the point at top line of cornice, which will give the pitch line of roof; 12 inches is therefore the base of the triangle, 10 inches its vertical height, and the slope or pitch length, the hypotenuse. Now draw the thickness of the roof boarding, 1 inch, and the depth of rafters, 6 inches; these lines when drawn will show the foot-cut on the end of the rafter where it rests on the wall plate. A section of the rafter, called the *toe*, runs over the plate to support the roof boarding, to which the eave mold can be attached. Now draw the boarding of the gutter, as shown. Observe that the corona of the cornice and the gutter are supported by the strip that is run out from the floor joist, to which it is spiked, and which is called the **lookout,** or cantilever, and is usually from 1½ inches to 2 inches thick, to insure strength and thickness for nailing the boarding and blocks to it, which form the cradle of the gutter. Now draw the plaster cornice and complete the figure.

Next draw Figs. 7 and 8, which are details relative to the construction of the front and side verandas, Fig. 7 being a one-half elevation of one of the bays, or divisions, of the front-veranda arcade, and Fig. 8 a transverse section of same. Begin by drawing the center line *q r* of Fig. 8 at a distance of 1½ inches from, and parallel to, the right-hand

border line. Then draw the top line of the water-table, at a distance of 3¾ inches from the lower border line, and parallel thereto draw the ground line at a distance of 3 feet below, and parallel to, the top of *W. T.* Subdivide this distance with horizontal lines, beginning at the top, with 7½ inches for base of post, 7¼ inches for floor and facia, 17¼ inches for height of pier, and 4 inches for ground table, or sill. At a distance of 4½ inches to the left of center line *q r*, draw the outer face line of pier, and 7½ inches to the right of center line draw the inner face line of pier; at a distance of 2⅞ inches from outer face line of pier, draw the edge line of floor; from the intersection of the edge line with the floor line, draw the upper face of floor to a pitch of ¼ inch to 1 foot; draw the thickness of floor, 1¼ inches, and draw the lower edge of floor joist which rests on top of pier. Draw the front beam or joist, as shown, 4 inches thick, the back face being on the center line *q r*. Then draw the facia and bed mold, and the screen frame with the strips that keep it in position, the bottom strip being secured to plugs inserted in the stone sill. Having finished the pier and floor construction, draw a line at a distance of 8 feet 9 inches from top of *W. T.*, which will be the height of window lintel marked *W. L.*, with which the top edge of the frieze of arcade is in line. The value of these lines will be fully understood when the elevation of the building is projected in a subsequent plate. Beginning at the top of *W. T.*, subdivide this distance with horizontal lines, 2¼ inches for lower block of baluster, 14¼ inches for the height of the turning of baluster, 2 inches for upper block of baluster, 2 inches for baluster rail, and 2 inches for cap rail, 4 feet for shaft of post above cap rail, 9½ inches for capital of post, 13¾ inches for the rise of arch, 4¾ inches to top of astragal member, 6½ inches for the frieze, 8¼ inches for the cornice, of which 3½ inches is for the bed mold.

Now draw the face lines of post and frieze, which, being 7 inches, will be 3½ inches on each side of the center line, and draw the projection of cornice 15 inches from the frieze line. From the intersection of this line with the crowning

line of cornice, draw the pitch line of roof (the pitch is 4 inches to 1 foot); then draw the roof boarding, rafter, and ceiling joist, the lower edge of the ceiling joist being 2 feet 5½ inches above the top of capital of post. The ceiling joists on which the rafters rest are supported by a longitudinal beam, which is 4 inches thick by 10 inches high. After drawing the beam, draw the cornice molds. Observe that the arch-key block projects ½ inch below the soffit, or under face of the arch. Draw the molds comprising the capital of the post, the measurements of heights and projections being given on Fig. 7. Then draw the channels cut across the face of the post to define the pedestal block on the post. Draw the section of balustrade composed of the cap rail, baluster, and base rail; the moldings of the baluster can be drawn with the bow-pencil; after which, join the curved members with straight lines as required.

After completing Fig. 8, proceed with Fig. 7. Begin by drawing the center line st at a distance of 1 foot 10 inches from, and parallel to, center line qr, and draw center line uv at a distance of 4 feet 4⅝ inches from, and parallel to, st. Then draw the thickness of the post, of which uv is the center line. Project all the horizontal lines from the post in Fig. 8, and finish the base pedestal block and the capital of the post. Observe that a flat disk is formed in the face of the pedestal block by cutting a channel, or groove, around same. Now draw the pier, ground table, screen, and floor finish by first projecting the horizontal lines from Fig. 8. From the intersection of the ground line with the center line st, with a radius of 10 feet 9½ inches, describe the soffit line of the arch, making it compound by uniting the small curve, which has a radius of 5¾ inches, the center of which is on the line defining the top of capital. Increase the radii $\frac{7}{16}$ inch for the line of fillet, and 1 inch from the first measurement for the edge of angle mold. Now project the horizontal lines of the cornice, etc. from Fig. 8, and draw the **triglyphs,** or grooved tablets, which are shown on the frieze, one being placed over the center of the post, and one over the center of the arch, where the key block of the arch is

treated as supporting it. At the triglyph over the post, the fillet of the astragal is widened, to show extra support for it, the lower end being cut into a series of dovetail guttæ, or drops.

Now draw the balustrade, projecting the members from Fig. 8; lay off the balusters, first marking a point 1½ inches (one-half the width of baluster) on the face of the post. Then divide the distance between this point and the center line *p t* into eleven equal parts; the points of division will be the center lines of the balusters. Draw these center lines full height of balusters. Then lay off the edges of balusters by the dividers from the center lines; locate the centers of the baluster moldings and describe the curves, after which draw the straight lines between the curves and complete the figure.

Now ink in the figures, draw the dimension lines, write in the dimensions, and letter the figures, titles, and other items of information, where shown on the engraving.

DRAWING PLATE, TITLE: FRONT ELEVATION

16. This plate shows a **vertical section** through *A B* indicating the mode of constructing the wall of the building, and the leading measurements from which the structure would be erected. This section carefully drawn will give the accurate position of the various horizontal subdivisions of the wall, from which all the horizontal lines on the elevation will be projected. The remainder of the plate is occupied by the **front elevation of the suburban residence,** of which the student has already drawn the first-story plan, the second-story plan, and the plate of details, the figures of which, he will readily observe, are incorporated in the elevation, and will thus be enabled to draw the elevation more intelligently.

The drawing is to be made to a scale of ¼ inch = 1 foot. First draw the vertical section, in which the greatest care and precision should be used in order to secure a satisfactory

projection of the elevation. Draw the outer face line of wall above the water-table, at a distance of $\frac{7}{8}$ inch from, and parallel to, the left-hand border line, and draw the ground line at a distance of $\frac{5}{8}$ inch from, and parallel to, the lower border line. Draw the first-floor level at a distance of 3 feet above the ground line, the second-floor level at a distance of 10 feet 10 inches from the first-floor level, and the attic-floor level at a distance of 10 feet above the second-floor level. From each of these floor-level lines draw the lines representing the floor, the depth of joist, and the lath and plaster on the ceiling. Observe that the first and the second floor are double, that is, consist of two thicknesses. Now draw the cellar wall, or, rather, that portion of it which projects above the ground line. This section of the wall is sometimes called *underpinning*, and it is usually faced with dressed stonework, or pressed brick superior to that in the body of the wall. The wall is 18 inches thick, and its face line is 4 inches in front of the face line of the upper wall. The face above the ground line consists of a ground table 4 inches thick, which projects $1\frac{1}{4}$ inches in front of the wall, three ranges of regular coursed ashlar or squared stonework, and a water-table, the upper surface of which is cut with a wash, or inclined surface, to shed the water. Draw these courses and show their width on the bed in the wall. Observe that the courses vary in width alternately (this is what is called the **bond** in masonry), and that the end of the floor joist is cut on an angle. This allows a joist to deflect under a load without straining the wall over it, and in the event of a fire the joists can fall downwards without overturning the wall. In a building of this character, however, these advantages are of no great importance.

Now draw the first-story wall, which is 12 inches thick, and built of brick, up to the top of stone lintel course, which is 8 feet 9 inches above top of water-table. At this level draw the wooden sill, which is 4 inches thick, on which is erected the frame wall of the upper story. Then draw the wall sheathing, which is 1 inch thick, and is brought down to the bed of the sill; the width of studding, which is 5 inches;

and the lath and plaster, 1 inch thick. Draw the top line of plate of frame wall, which is 12 feet 10 inches above the top of lintel course. The plate is composed of two thicknesses of scantling, each of which is 2 inches thick and 5 inches wide. Draw the pitch line of roof from a point that is at the intersection of the projection line of cornice, 18 inches from frieze, and a horizontal line drawn $11\frac{1}{4}$ inches below top of wall plate; parallel with the pitch line of roof draw the roof boarding and the lower edge of rafter, after which draw the outline and construction of the main cornice, taking the measurements from Fig. 6 of plate entitled, Details. Then draw the molded course above the stone lintel course, the particulars of which are shown in Fig. 5 of the same plate.

While this section is on line *A B*, and would therefore not show the position of the window openings, still, for convenience, the necessary data are drawn on this plane, as shown by dotted lines. The height of the window sills from the floor and the distance of the lintels from the ceiling will determine the height of the windows. Having finished the vertical section, proceed to develop the front elevation, which, as in Fig 2 of the previous plate, is done by projecting those structural lines of the building, which would be seen when viewing it from the front, on a plane assumed to be in advance of the building, this plane being at right angles to its axis, as center line *a b* on the first-story plan, and perpendicular to the floor level, the points for the vertical lines being transferred from the first-story plan and the horizontal lines from points on the vertical section, which has just been drawn. The point of sight is assumed at all times to be at right angles to this plane of representation.

Begin by drawing the center line *a b* (which occupies the same relative position as the center line *a b* on the first-story plan), at a distance of $8\frac{1}{4}\frac{3}{8}$ inches from, and parallel to, the left-hand border line, and draw the ground line at right angles thereto, projected from the ground line of vertical section. Now draw the vertical center line *m n* from the position of the center line of bay window on first-story plan,

and also the center lines *q r* and *s t*, all of which are to be parallel to center line *a b*, their correct location to be ascertained from first-story plan. Project all the horizontal lines from the vertical section, drawing them with great care, as a slight deviation will alter the proportions of the molded sections. As the top of the eave molding on the gutter in main cornice is the highest point drawn in the section, only those horizontal lines which are below this can be procured from the section. Commencing at this line, work downwards, drawing fine horizontal lines the full width of the sheet, leaving their terminations to be defined when the vertical lines are projected. The lines of the crowning member of the veranda cornice and the lines of the veranda gutter are not shown on the vertical section, and points for these must be obtained from Fig. 8 of the previous plate. Now project the window lintel, sill, and frame lines, and the top line of water-table from the section; also, the lower line of the cellar-window lintels, which is also the line of the lower edge of floor facia, but do not, as yet, draw any of the joint or wash lines of the ashlar masonry, as they would be likely to cause confusion. On the top line of water-table, which has been projected from the vertical section, locate the points that define the position of the structural lines which the first-story plan presents to this plane.

Working to the left of the center line *m n*, take the following measurements from the first-story plan, marking them on the elevation as they are taken off: 3 feet to external angle of window, the angle where the side of the bay window intersects the house being 3 feet therefrom; adding this measurement to the first will give $3 + 3 = 6$ feet as the distance from center line *m n* to the intersection with the house line. The angle of the building is 9 feet 9 inches from center line *m n*, and the wing wall of dining room advances 2 feet 6 inches beyond this. To the right of center line *m n*, the distance to external angle of window is 3 feet, and, as above stated, 6 feet to the reentering angle. Now, starting from center line *a b*, to the left is a distance of 2 feet 6½ inches to the center line of window, and to the right

2 feet 2½ inches to center of the doorway, then a distance of 3 feet 4¾ inches to the return angle of brick wall, which gives 5 feet 7¼ inches from center line *a b*; from this wall, at a distance of 3 feet 4⅝ inches, is the center line *q r* of window, already drawn; at a distance of 3 feet 11⅞ inches is the angle of intersection of the curved wall of the tower with the face line of wall, and which should be 4 feet 1½ inches from the center line *s t* of the tower. From this line to the right, at a distance of 6 feet 6 inches, mark the point that shows its semidiameter; these points being marked with the needle point on the top line of water-table, commence at the right, at the last point plotted, and work back to the left, checking the measurements by reference to the first-story plan, as upon the accurate location of these points depends the value of the drawing. Having checked in this manner, further check a total measurement of the distance of the point limiting the curved wall from the center line *a b*, which should be 23 feet 7¼ inches, the projection of the curved wall from the straight return wall. Lay off to the left of center line *a b* a distance of 14 feet 1¾ inches to the center of the bay window; this distance, added to the distance of 9 feet 9 inches from center of bay window to angle of parlor wall, gives 23 feet 10¾ inches. Now check the total frontage that the building presents to the plane, which should be 50 feet. If all the points have been transferred correctly, draw from them lines perpendicular to the top line of the water-table, continuing them up to the line of the lower edge of the frieze of main cornice.

From the center lines of window openings mark a distance on each side equal to one-half the width of the opening, and draw the lines from the sill to the under edge of stone lintel course. This being done, lay off a point 2 inches from each of these jamb lines just drawn for the width of the window frame, and another one 2 inches from the first for the width of sash to the glass line. This may be done by means of the dividers set to 2 inches. This space can be laid off at all the jamb lines, and then, setting the dividers to 4 inches, the sash line can be marked. Draw all these lines parallel to the jamb lines. The frame width

under the lintel will have been already projected from the vertical section, so draw the sash width 2 inches therefrom. Now draw the sill of window frame and the sill of lower sash. The sill of window frame is 2 inches thick, the upper surface from the outer edge to the outer face line of sash being worked to a pitch of $\frac{1}{2}$ inch. The sill of the sash is $3\frac{1}{2}$ inches deep, which makes a total of 6 inches from top of stone sill to the upper edge of sash sill, or lower rail, as it is sometimes called. Now divide equally the distance between the lower edge of the upper rail of upper sash and the upper edge of the lower rail of lower sash, which will give the center line of the meeting rails. Observe that, while only one rail is seen, there are really two, the meeting rail of the lower sash being situated immediately behind that of the upper sash, which is shown. The stiles of the upper sash are extended below the line of the meeting rail to give additional strength, and molded as shown.

Having finished the windows, which are straight and parallel to the plane of representation, draw the window frames and sash of the side openings of bay window. The walls in which they are placed being turned at an angle from this plane, their actual measurements will not be projected on it. By reference to the first-story plan, it will be seen that, while the measurement of the side of bay window is 4 feet 3 inches, this is reduced to 3 feet, when projected to the line of the front wall of window. Any subdivision on this line will be reduced in proportion. Observe, also, that one of the jambs is turned towards the plane of representation, while the other is turned away from it. In the former case the brick jamb and the jamb of window frame and the sash can be shown, while in the latter case none of these can be shown. Observe that all the lines of window frame are not shown, owing to the small scale, and that the lines of the outer lining of frame and the parting strip are omitted, for a similar reason. The jamb line of window frame is shown, but the $\frac{1}{2}$-inch projection of the outer lining is omitted. In this manner many of the minute details of construction are not designated on drawings made to this scale, which are called

general drawings, but the most minute must be shown on the larger scale drawings, called *detail* drawings. In order to fully understand these lines and the position that they should occupy on the elevation, make a detail drawing of the plan of the side window to a scale of $\frac{3}{4}$ inch = 1 foot (the position of the frame, with relation to the jamb, can be procured from Fig. 5 of the previous plate), and draw the sash stiles in the frame, as one is shown on Fig. 3 of the same plate. In this case show both sash stiles adjacent to each other. This being done, project the lines forward to the extended line of the front of window. The points on this line can then be measured, with reference to the jamb line, and transferred on the reduced scale to the elevation. This will constitute a practical exercise for the student, and he will have a more intelligent conception of the value of the lines. At the window opening in the curved wall, another exception to the mode of showing the window frame and sash in a straight wall may be noted. As the wall curves from the plane in the same ratio on both sides of the center line, a portion of both jambs will be seen, and seen alike, as shown.

Having finished the first-story windows, draw the entrance doorway. The door frame shows a molded edge, and the jamb stone and lintel are shown with a molded architrave worked on same. The door framing is arranged to show a series of six panels in the lower section, while the lock panel is the full width between the framing. These panels are shown with moldings around the framing; the center of the panels is raised, as indicated by the position of the shade lines. Observe that the framing of the door above the paneling is reduced in width, this being done to lighten the appearance around the glass panel, as explained in Art. **11.**

Now draw the windows of the second story. These being in a timber wall, the method of showing the window frame is quite different from that of the first story, as will be more clearly seen by reference to the previous plate. The window frame occupies the full thickness of the wall, and the outside casing has to be of sufficient width to cover the pocket for

the sash weights. A sub-sill is inserted under the regular sill of window frame, extending beyond the face of outside casing. In this case the sill is from 1 inch to 1¼ inches thick, and the sub-sill 1⅝ inches thick. At the bay window, a casing, or apron, is shown under the sub-sill. Observe that the section of the apron under the angle casings is increased in depth. This is to give an appearance of additional support for these casings. The window in the tower not being protected by the main-roof cornice, has the cap, or drip member, to throw the water drip clear of the casing. Draw the triglyphs on the frieze. By referring to the second-story plan, it will be seen that the wall surface adjacent to the center line $q r$ recedes 18 inches from the face of the dressing-room wall, which necessitates consideration of the cornice treatment, unless an increased amount of projection is given to the cornice. In cases like this, the usual course is to raise the cornice to suit. In order to retain the general cornice level, however, the wall surface is continued above it, and finished at the intersection of the roof plane with an eave mold.

Now draw the roof lines; as will be seen on the engraving, the ridge line, or intersection of the inclined planes of the main roof, is located at a height of 13 feet 7¼ inches above the eave line. At a distance of 4 feet 5¼ inches below the ridge, draw the eave line of the truncated section of the roof. The intersection with the ridge will be found to be on a line with the reentering angle of the bay window. Having fixed this point, draw the gable-cornice projection, which is 18 inches from the frieze line. From the point of intersection of this line with the eave line already drawn, draw the slope line of the truncated section to the point on the ridge. Draw the ridge line of the roof over the dining-room extension, which is 7 feet 7 inches above the eave line, and the gable-cornice projection 18 inches from frieze line. Now draw the returns of the cornice molds at the eaves, as shown. Draw the portion of the cornice of the kitchen wing which is seen beyond the wall of tower. By reference to the second-story plan, it will be seen that the center of tower is

5 feet from the outer face line of wall of the stair hall, that the wall of kitchen wing advances 12 inches from same, and that the cornice projects 19½ inches from the face of this wall, which will give a measurement of 7 feet 7½ inches, the distance from center line of tower to the eave line of the kitchen cornice. Now locate the ridge intersection of the roof plane over the kitchen wing. First draw the line of the wall, which is 19½ inches from the point just marked. By reference to the second-story plan, it will be seen that the ridge is 14 feet 3 inches from face of wall. Measure this distance on the eave line of cornice and mark a point, and from this point draw a perpendicular line. Its intersection with the ridge line will be the point desired. Connect this point with the eave line; this will define the roof plane. Draw the stone chimney, first locating the center line *o p* at a distance of 6 feet 2 inches from the center line *a b*, and drawing a series of horizontal lines above the ridge line from the dimensions given, locating the line of the top of the chimney base 12½ inches above the ridge; then indicate a course of 8 inches, the height of the panel 24 inches, an architrave course of 10 inches, the frieze and bed mold 15 inches, the cap 14½ inches, and the terra-cotta flue caps 11 inches in height. Draw the vertical lines from the dimensions given on each side of the center line, 19 inches for the width of base, 17 inches for the shaft, and 9 inches for the panel. Other dimensions can be obtained by scale measurements. Observe that the flue caps are square on plan at the base, and are drawn into an octagonal form at the top, and that the triglyphs have flutes, or grooves, cut in the face. Having completed the chimney above the ridge line, it will be necessary to find the line where the base intersects the inclined roof plane in its passage through the roof. Draw an outline of the roof planes as shown in Fig. 1, the vertical line defining a plane passing through the ridge. This figure is a view of the roof as seen from the end of the building, looking towards the chimney. As the base is 13 inches to the right of the vertical line, this line when drawn will give the point of intersection with the

roof plane, from which a line can be projected over to the chimney.

Now draw the dormer-window over the bay window. The term **dormer-window** is applied to a window rising from the slope of a roof. Lay off the wall lines 6 feet from, and parallel to, the center lines *m n*, draw the cornice projections 16 inches from the wall surface, and at a distance of 6 feet 1¼ inches below the ridge line, draw the eave line; as the ridge line of the dormer-window is the same height as the ridge line of the main roof, connect this point by lines to eave points already found, which will give the inclined planes of the roof, and which should be parallel to the slope line of the truncated section of the main roof. Draw the inclined and horizontal cornice and frieze lines from scale measurements, locate the door and window openings and their casings by similar means, and draw the semicircular door head and architrave casing; after which draw the framing of the door and the window sash and draw the balustrade in front of the dormer-window, taking all the measurements and details from Fig. 2 of the previous plate.

Draw the smaller dormer-window, which is located on the center line *a b*, by first drawing the roof planes. Observe that the eave line is level with that of the large window adjacent, and that its distance from *a b* is 35¼ inches. From this point draw the left-hand roof plane parallel to that of the large window, and draw the right-hand plane in a similar manner; from the ridge, measure down 3 feet to the center of the circular opening, and draw the circular lines that represent the sash and framing, securing the dimensions by scale measurements from the engraving. Draw the lines that denote the width of the window, 21¼ inches on each side of the center line, after which draw the sill and apron; finish the cornice with the corbel blocks projecting from the face of the window returns or flanks, and the pateras, or saucer-like ornaments, sunk in the face of casing to relieve the wide surface.

Now draw the terra-cotta ridge coping and finials on the main roof; the coping is in 12-inch lengths, the joints of

which are shown, and draw the ridge coping of the roof of dining-room extension and the finials of the roof dormer-windows.

To finish the roof and cornice of the circular tower, begin by drawing the eave line of cornice at a distance of 10 feet 1 inch above the eave line of main cornice; then complete the cornice and frieze by scale measurements from the engraving, and draw the double window on front and that portion of a similar window, which, while facing on the side elevation, by following the curved plan of tower, presents a portion to the front elevation. By drawing the plan of the window in position and projecting the lines forward to the front line of the building, their accurate position on the elevation can be determined.

To draw the curved outline of the roof, first locate the centers from which the curves are struck, from the measurements given, and draw the curves with their respective radii. Having drawn the right-hand curve, locate the centers on the left-hand curve, and complete. The curve, or flare, at the base of the roof is sometimes called the *bell-cast*, from its resemblance to a bell, while the roof proper is called an *ogee* roof from its form.

Draw the finial at the apex of the roof as shown, which consists of an apron, base, shaft, and foliated cap.

Having finished the tower roof, draw the curve that denotes the line of intersection of the roof plane with the circular wall of tower. This is an application of Fig. 4 of plate entitled, Intersections and Developments, *Geometrical Drawing*, and is explained in Art. **43.** First draw a semicircular curve with a radius equal to the semi-diameter of the tower, the center being located on the center line $s\,t$ adjacent to the curve and at right angles to its axis $w'\,x$. Draw a line $v\,u$ to represent the horizontal plane at the eave line $u'\,x''$, the point u being at a distance of 5 feet 4 inches from v. From u draw the slope line $u\,w$ of the roof, the pitch being 10 inches to 1 foot; project u to a point u' on the curved line of the tower, and divide the arc $u'\,w'$ into five equal parts; transfer these points to the roof line $u\,w$ by lines drawn

parallel to $w' x$, and again transfer points on the roof line to the line $u y$, which is perpendicular to $v u$; at u'' erect a vertical line $u'' y'$, on which lay off spaces equal to those on $u y$. Now project from the points on the arc vertical lines down to the curved face of the tower. The intersection of these lines with horizontal lines projected from the points on $u'' y'$ will give points on the desired curve; draw a line through them by means of an irregular curve, and draw the outline of the eave mold and facia as shown, which abut against the wall of the tower.

Proceed to draw the veranda by first locating the center lines of the posts, procuring the measurements from the first-story plan, and starting from the center $a b$ on plan and elevation. Draw the lower edge of the floor facia at a distance of 14¾ inches below the top of water-table. Then draw the width of the facia, the thickness of the floor, and the bed mold, the total width being 7½ inches, as shown on Fig. 8 of the previous plate. Draw the width of the posts, which will be 3½ inches on each side of the center lines already drawn; after which draw the vertical subdivisions of the posts, the frieze, and cornice, procuring the dimensions from Fig. 8 of the previous plate. Draw the returns of the post bases and caps and the arch heads which rest on the post, from the dimensions given. Observe that all the curves start tangent to the caps.

To draw the arches which are set obliquely to the face line of the veranda requires a different method. As their face is turned away from the plane of representation, the lines appear shorter and distorted on the elevation, and a portion of the soffit, or under side of the arch, is brought into view. The method of developing the curved lines will be illustrated on the next plate, so that for the present a method of reproducing the curves on the drawing from the engraving will be employed. Draw a line connecting the caps of the posts at the springing line of the arch to the right of the tower, and draw a center line *1–2* perpendicular to same. For the curve on the outer face, divide the line *2–3* into four equal parts, and draw lines from these points parallel to *1–2*. The length

of these lines, or ordinates, as they are called, will define the points on the curve, and they can be procured by scale measurements from the engraving. Join the points by an irregular curve. This will give the curve to the left of center line *1–2* ; the curve on the outer face to the right of the center line *1–2* will be similar. To draw the curve of the inner face, divide the line *2–4* into four equal parts, and proceed as before. The oblique curve at the junction with bay window should be drawn in a similar manner.

Draw the pediment cornice over the entrance to doorway, and the arch key, the triglyphs, and the cornice and bed-mold returns. The position of cornice returns should be taken from second-story plan; draw the lines that denote the gutter along the eave of the cornice.

Next draw the line that defines the intersection of the veranda-roof plane with the wall surface. That portion of the roof adjacent to the center line $q\,r$ intersects the wall surface at a height of 3 feet 1 inch above the eave line of cornice. Where the roof abuts against the circular wall of tower, the line of intersection will be curved as shown. Points in this curve can be found by the process used to find the intersection of the main roof with the tower. First, locate the point where the hips of veranda roof meet on the tower wall; draw a line $c\,d$ at a distance of 5 feet from, and parallel to, the center line $s\,t$, which is the face line of wall behind the tower. By referring to the second-story plan, it will be seen that the point where the hips meet is 5 inches from the face line towards the center line of tower. Draw this line $h\,i$ also parallel to $s\,t$; draw a horizontal line $e\,f$ at a distance of 3 feet 1 inch above the eave line of cornice, meeting $c\,d$ in e; through e draw $r\,e\,p$, meeting $h\,i$ in p, which is the desired point; from p draw the hip lines $p\,q$ and $p\,r$. To find the curve, draw a line $j\,k$ at right angles to $w'\,x$; this will represent the horizontal plane at the eave line of veranda cornice; from j' project a line to j on line $j\,k$; from j draw the slope line of roof $j\,l$, which has a pitch of 4 inches in 1 foot; on the base line $j\,k$, from the point j, lay off a distance of 23 inches and draw a perpendicular line, passing

through $j\,l$ at p', which is the horizontal distance that the point p on the elevation recedes from the point m on the face of tower at the center line $s\,t$; from p' project a line meeting the curved outline of tower at p''. Divide the arc $p''\,j'$ into four equal parts and project the points found on the arc down to the slope line $j\,l$; from the points on $j\,l$ draw lines parallel to $j\,k$ and intersecting $l\,k$, which will give the vertical height from base line $j\,k$; transfer these heights to the center line $s\,t$, from the point m thereon; from the points marked on $s\,t$ draw horizontal lines to $h\,i$; then, from the points on the arc $j'\,p''$, draw vertical lines; the intersection of these lines with the horizontal lines will give points on the desired curve; through these points draw the line of intersection by means of an irregular curve. To draw the curve on the left of center line $s\,t$, transfer the points from the curve just drawn; only a portion of the curve will be required, as $n\,m$ is shorter than $m\,p$.

From m project the line $o'\,p'$; as m advances the same distance from the wall surface at $q'\,n$ as the wall surface at $o'\,p'$ does, the curved line $p'\,q'$ should be drawn by the same method as $m\,p$, since the wall surface at $p'\,q'$ is a quadrant of a circle having a radius of 18 inches, as seen by reference to second-story plan. The position of the hip lines $o'\,r'$, $o'\,t'$, and $r'\,s'$ can be determined by also referring to the second-story plan; $o'\,r'$, while drawn as a straight line, would be very slightly curved in construction, as the roof plane intersects the flare of the wall surface of the bay window.

Draw the balustrade of the veranda, procuring the dimensions from Fig 8 of the previous plate. Observe that only a few of the balusters are drawn in full; the others are shown with top and bottom blocks and center lines.

Draw the cellar windows, the piers for the support of the veranda posts, the screens between same in position, and the stone steps leading to the veranda floor. The lines for the courses of the masonry can be projected from the vertical section. Lay off the length of the stone blocks by scale measurements from the engraving, after which the drawing should be carefully compared with the original, and any

omission rectified and the lines inked in, the curved lines being drawn first. The lines used for the development of the curved surfaces should be neatly inked in, with broken and dotted lines, as shown. The reference figures and letters may be omitted; but the figure dimensions should all be indicated, as they form important parts of the working drawing.

DRAWING PLATE, TITLE: SECTIONAL ELEVATION

17. Fig. 1 of this plate shows a **sectional elevation,** or longitudinal section on the line *g h i j k l*, as marked on the first and second story plans, and presents such a view of the interior as would be seen if the building were cut by a plane following the divisional line *g h i j k l*, and the front half of the building removed. Such sections are drawn for the purpose of showing the interior arrangement on the vertical plane, as the plans show the arrangement on a horizontal plane, and while constituting an elevation of the interior, as presented to the plane of the section, it also exposes what may be termed the anatomy of the structure, and shows the relation that exists between the several parts. A better knowledge of the structural value of the lines can therefore be ascertained from such sections than can be secured by the study of either the plan or the elevation.

This section is also to be drawn to a scale of $\frac{1}{4}$ inch = 1 foot. Begin by drawing the center line *a b*, at a distance of $8\frac{3}{4}$ inches from, and parallel to, the left-hand border line. Then draw the ground line at a distance of $2\frac{1}{4}$ inches from, and parallel to, the lower border line. At a distance of 3 feet from, and parallel to, the ground line, draw the top of water-table, which is also the level of the first floor. This constitutes the base line, from which all vertical lines are measured.

At a distance of 9 feet $\frac{5}{8}$ inch below this line, draw the top line of the cellar floor; then, at a distance of 10 feet 10 inches above top of water-table, draw the top line of second floor. As the distance from second floor to attic

SECTIONAL ELEVATION.

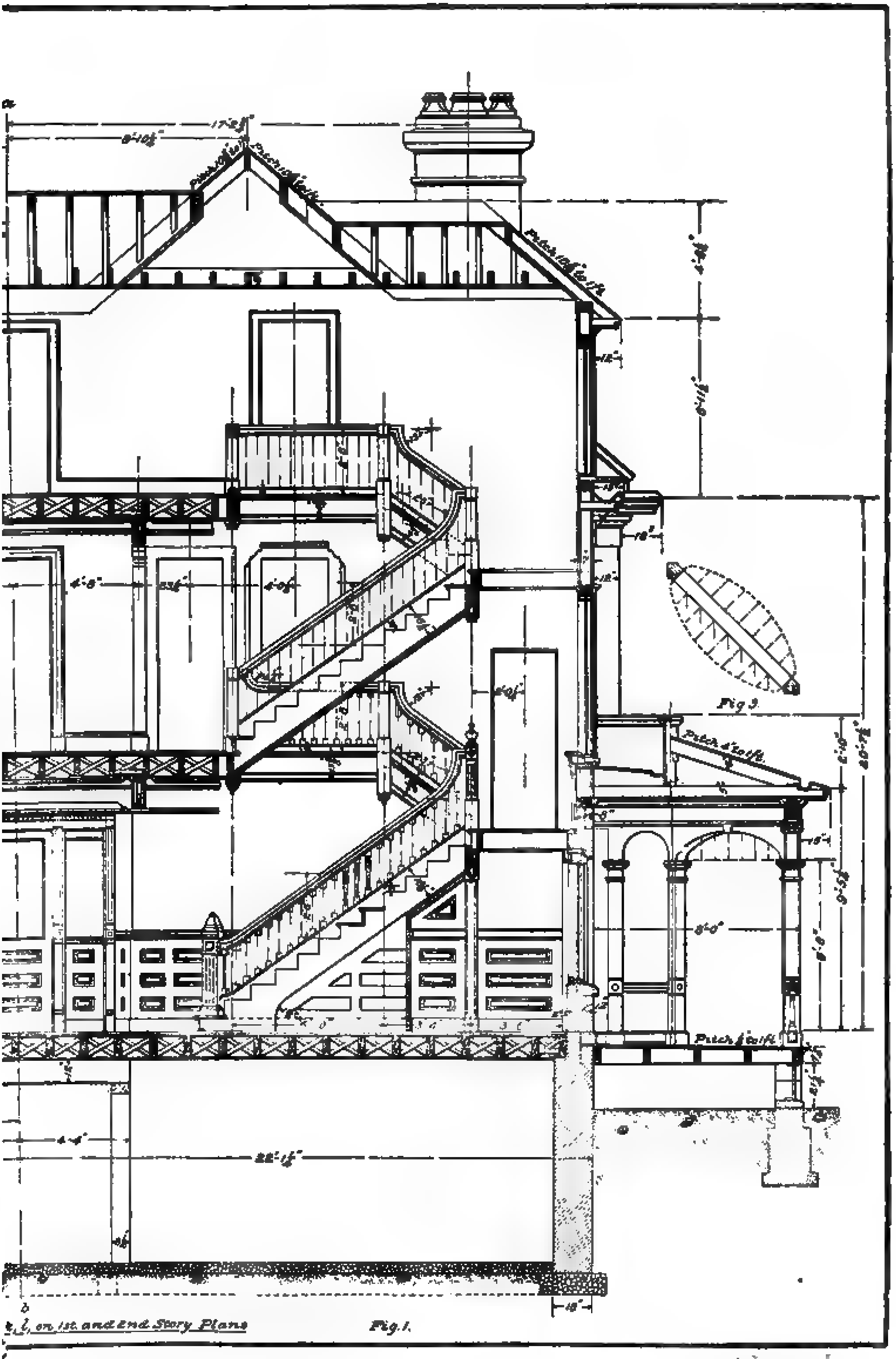


Fig. 3
Fig. 1.

floor is 10 feet, add this to the first measurement, thus making 20 feet 10 inches from the base line to the attic floor. The clear distance between attic floor and ceiling being 8 feet, will give 28 feet 10 inches from base line to attic ceiling. Having located these points, draw through them horizontal lines of indefinite length. Now proceed to develop the section. Begin with the cellar. Draw the flooring and the joists and ceiling over the cellar. The joists are 3 inches thick, and are set at 16 inches between centers. The crossed strips between them are called cross-bridging, and serve the double purpose of keeping the joists from twisting and distributing the weight of the floor when unequally loaded. Before laying off the joists, draw the outer and inner walls of the cellar, with their footings, or base, of concrete. The outer walls are of stone and 18 inches thick; the central wall is of brick, with concrete base, and is 17 inches thick, to which is attached a section of the wall of ash-pit under the parlor fireplace. This gives an additional width of 21½ inches. Since the section plane passes obliquely through the face and return of the wall of ash-pit, it presents this wide surface. As shown, three courses of the brickwork are corbeled out to receive the ends of joists, and an iron door and frame are shown at the base. Draw the arched opening in the wall under the parlor door, the pier supporting the 12-inch beam under the joists of hall, and the angle of the wall under stair-hall partition, which is 4 feet 4 inches from center line *a b*.

The cellar floor is shown constructed with 5 inches of concrete, and the footings of walls, with concrete 10 inches thick.

Now draw the outer walls of the superstructure, above the top of water-table, from dimensions given, and get the subdivisions by scale measurements. Draw the central partition in a similar manner, leaving the work above the attic ceiling to be drawn later. From the second and attic floor lines lay off the ceiling lines. The figured distances will be found by reference to the vertical section on the previous plate.

The drawing will now present six compartments above

the cellar, three of which will be occupied by the stairways and halls, and should be filled in successively.

Draw the stairways first. The stairways have already been represented on plan and will now be developed in elevation. Locate the center lines of newels, and draw them parallel to the center line *a b*; now divide the distance between the top line of first floor and the top line of second floor into eighteen equal parts, and the distance from second floor to attic floor into seventeen equal parts, by fine pencil lines. Mark off on the first-floor line the number and width of steps of the first flight as shown on first-story plan; working from the center line of the platform newel. As the first three steps are curved on plan, take their width on the section line *i j* of first-story plan; from the points marked on floor line draw lines parallel to center line *a b*; the intersection of these vertical lines with the horizontal lines already drawn will give the riser and tread lines of each step and the position of the first platform; project these vertical or riser lines up to the second, third, and fourth flights, excepting, however, the riser lines of the curved steps at start of stairway. These riser and tread lines should now be strengthened by a heavier pencil line and the lighter lines erased. Now draw the upper edge of the inclined stringers, which, as shown, is 3 inches above the tread, measured on a line with the riser. Draw the lower edge parallel with the upper edge, and make the stringers of the widths shown, observing that both the upper and the lower edges at the start are curved. Then draw the upper edge of hand rail, which is on the stair 2 feet 6 inches above the tread, measured on the riser line, and on the landing 2 feet 8 inches above the floor line. Having drawn this line, draw the ramps, or curves, which are introduced for the purpose of raising the hand rail up to the same height as the one on the return flight, and at the landings to the height of the landing rail. The newels on the platforms and landings are then all of the same height. Observe that there is a horizontal knee 6 inches long on the upper edge, between the ramp and the newel.

Now draw the width of the shaft of each newel, which is 5 inches, and the width across the base 6 inches, excepting, however, the start newel, which is 7 inches square above the base; draw the depth of the hand rail, which is 4 inches, with the molded members as shown. This being done, draw a cap 1 inch thick on the upper edge of each stringer, and fill in the balusters, as indicated, subdividing the newels with base, shaft, cap, etc., as shown. On the lower edge of the stringer of the flights, through which the plane of the section passes, will be shown the lath and plaster and the soffit mold, to bind the plastering at its junction with the face stringer, while on the face of the other flights and landings will be shown the face molds, which divide the stringer into architrave, frieze, and base for balustrade. All the newels will have finials, and those disengaged will have pendants, but those on the first flight are only shown, to indicate the general finish.

To draw the start newel, the angles of the newel should be projected forward to section line ij, on first-story plan, and transferred to the drawing being made. Complete the other details of the stairways, as shown. Then proceed to fill in the finish shown in first floor, including ceiling beams and cornice, door and window trim, and the wainscoting, which should be drawn to scale measurements, taken from the engravings. Draw the door and corbeled-beam opening in the partitions of second-story hall, with the base and door trim, ceiling beam and cornice, and also the door openings, with base and trim in the attic hall.

Then draw the double door in parlor, with trim, base, and ceiling cornice, and the angular fireplace and chimney, the position of which can be procured by projecting the angle lines forward to the line of section gh, on first-story plan, and then transferring them to the drawing.

Draw the door and partition openings, and finish in the rooms over the parlor, as shown. The space marked R indicates the position of the hot-air register over the base.

Draw the elevation of the dining-room extension, which is seen beyond the plane of the section on the left, and the

section of the veranda and kitchen extension, which is on the right. The details of the veranda should be procured from Fig. 8 of plate entitled, Constructive Details.

To develop the oblique curve, first draw the plan of the return of the veranda, as shown in Fig. 3, and draw the normal or regular curve adjacent to its face. Divide the diameter into eight equal parts, and draw ordinates at right angles to the springing line of curve. To draw the curve on the inside of veranda, project pencil lines from the points on the springing line of the lower curve down to the springing line of curve on the elevation, and transfer the lengths of the ordinates on the plan down to the elevation; these lengths, measured from the springing line, will give points on the desired curve.

The outer curve on the elevation is drawn in a similar manner, by projections and measurements from the upper curve on the plan.

To show the relative position of the roof lines, rafters, and ceiling joists to the line of section, begin by locating and drawing the main ridge line, which is 13 feet 7½ inches above the eave line of the cornice; then make a diagram like Fig. 2, showing the rafters and boarding, the upper surface of which is the roof plane; the vertical line passing through the ridge represents the ridge plane. On each side of this plane draw the position of the section planes represented by lines *g h* and *i j*. By reference to the second-story plan, it will be seen that *g h* is 4 feet to the right of the ridge line, while *i j* is 24½ inches to the left of the ridge line. This accounts for the difference in the position of the rafters on each side of center line *a b*. From Fig. 2, project the line at the intersection of the cutting plane *g h* with the roof plane, which is the upper edge of the roof boarding; also, the line of the toe of the rafters; then draw the upper edge line of the ceiling joists, and from the inner wall line mark off the rafters 16 inches between centers. To do this, draw the first rafter in position at the wall; then set the dividers to 16 inches, and, starting from the center line of the first rafter, mark the points on the boarding line up to the center line *a b*;

then, from these points as centers, with a radius of 1 inch, describe light pencil circles, from which draw the faces of the rafters; draw the legs of rafters down to the ceiling line, and from the right face, with the bow-pencil set to 2 inches, mark the thickness of each ceiling joist forward to the center line *a b*.

From *i j*, on Fig. 2, project the rafter lines as far as the valley rafter, and draw the valley rafter in position, as shown; it supports the short, or jack, rafters. At a distance of 8 feet 10¼ inches from center line *a b*, the section plane cuts the ridge of the kitchen extension, and to the right of the ridge it cuts the valley rafters of the roof of dormer-window, over the stair hall. Observe that a portion of the ceiling in the stair hall has to follow the inclination of the rafters, and is known as a *canted* ceiling.

Draw the chimney by scale measurements from the engraving and complete the drawing, after which it should be carefully inked in, and the walls and cross-sections of the timbers neatly sectioned, as shown, and the dimension lines drawn and lettered.

TRACINGS

18. In regular office practice, it is necessary to have more than one copy of a drawing. It would be very expensive to make a finished drawing every time an extra copy was wanted, and, to avoid this, tracings and blueprints are made. As many blueprint copies can be made as are desired from a single tracing. A complete pencil drawing is first made; then, instead of inking in the drawing as heretofore, a piece of tracing paper or tracing cloth, of the same size as the pencil drawing, is fastened to the board over the original drawing. The tracing paper or cloth being transparent, the lines of the drawing can be readily seen through it, and the drawing is inked in on the tracing paper or cloth in the same manner as if inking in a finished drawing.

Tracing paper is but little used in this country. It is easily torn, and cannot be preserved as well as the tracing

cloth. The two sides of the tracing cloth are known as the glazed side and the dull side. The glazed side is coated with a preparation of gelatine that gives it a very smooth, glossy surface; the dull side has very much the appearance of a piece of ordinary linen cloth. Either side may be used to draw upon, but when the glazed side is used, care must be taken to remove all dirt and grease. This can be done by sifting powdered chalk upon the tracing cloth and then rubbing it over the entire surface with a soft rag. It is not necessary to use chalk when the dull side is to be drawn upon, but it improves the surface to do so, and causes it to take ink more readily. The finished drawing looks better and will not soil so easily if traced on the glazed side, and it is easier to erase a line drawn on this side. Pencil lines can be drawn on the dull side, and if it is desired to photograph the drawing, it is better to draw on the dull side. The draftsman uses either side, according to the work he is doing, and to suit his individual taste; but if the glazed side is used, *it must be chalked.* The tracings are drawn in the same manner as the finished drawings, the center lines, section lines, etc. being drawn exactly as previously described.

After having drawn the last plate, the student should make tracings of the plates entitled, First-Story Plan, and Front Elevation, which should be finished and lettered exactly like the paper drawing.

BLUEPRINTING

19. Blueprinting is the name of a process by which any number of copies may be obtained from a single tracing. It is based upon the properties that certain chemicals possess, of changing color on exposure to the light; and its operation consists of subjecting to strong sunlight a sheet of prepared paper, which is covered by the tracing and held in close contact by means of a sheet of heavy glass. The light passing through the transparent tracing causes the paper to turn blue over all its surface, except where protected by the

opaque lines of the drawing, and thereby produces a print that duplicates the original drawing so far as lines and measurements are concerned, but in white lines on a blue ground.

Although it is usually much more economical to purchase blueprint paper ready for use, the ingredients are very simple, and in an emergency the paper may be prepared as follows: In a dark-colored or opaque bottle, dissolve 2 ounces of citrate of iron and ammonia in 8 ounces of water; and in a similar bottle dissolve $1\frac{1}{4}$ ounces of ferricyanide of potash in 8 ounces of water. These solutions should be mixed in equal portions immediately before use, as they deteriorate with age when mixed.

To sensitize the paper, a small quantity of the mixed solutions is poured upon the center of a sheet, and then, by means of a camel's-hair brush or tuft of cotton, it is spread evenly over the entire surface, and any surplus carefully removed. The paper is then hung up to dry, after which it is ready for use. All this must be done in a room lighted with gas, lamp, or weak yellow daylight, and the prepared paper must be kept in a cool, dry, dark drawer or closet, or it will lose its sensitiveness. In any case it does not keep well for any great length of time, and for this reason it is not desirable to prepare more than is needed for immediate use.

The paper used should possess a hard, close-grained surface, and should be well sized. Otherwise it will be necessary to mix about $\frac{1}{2}$ ounce of gum arabic with each of the stock solutions, to prevent the sensitizing liquid from sinking into the pores of the paper and thereby becoming difficult to wash out after the print is made.

Figs. 6 and 7 of the text are two views of a printing frame that is well adapted to printing blueprints not over 17 in. × 21 in. The frame is placed face downwards, and the back *A* is removed by unhooking the brass spring clips *B*, *B*, and lifting it out. The tracing is laid upon the glass *C*, with the *inked* side downwards, touching the glass. A sheet of the prepared paper, perfectly dry, is laid upon the tracing with the yellow (sensitized) side against the

tracing. The paper and tracing are smoothed out so as to lie perfectly flat upon the glass, the cover *A* is placed back into its former position, and the brass spring clips *B*, *B* are pressed under the plates *D*, so that the back cannot fall out. All this is done in a subdued light. The frame is now placed where the sun can shine upon it, and adjusted as shown in Fig. 7, so that the sun's rays will fall upon it as nearly at right angles as possible. According to the condi-

Fig. 6

tion of the weather, whether clear or cloudy, and the time of the year, the print should be exposed from 5 to 20 minutes. A tray or sink somewhat larger than the print should be provided, and filled to a depth of about 2 inches with water. The print having been exposed the proper length of time, the frame is carried into a subdued light, where the cover is removed, and the print taken out and placed in the water, with the yellow side down, and there left to soak while the next print is adjusted in the frame. The first print having been washed about ten minutes, it should be

lifted out by two of its opposite corners and rinsed thoroughly; then it should be hung up till dry. Should any dark-purple or bronze-colored spots appear on the print, after it is dry, they indicate that there was not sufficient washing. If these spots are thoroughly washed before the print is dried, they will disappear. It is best to judge of the proper time of exposure to the light by the color of the strip of print projecting beyond the edge of the tracing. To

FIG. 7

obtain the exact shade of the projecting edge, take a strip of paper about 12 inches or 14 inches long and 3 inches or 4 inches wide. Divide it into about twelve equal parts by lead-pencil marks, and number each part with the lead pencil 1, 2, 3, etc. Sensitize this side of the paper, and, after it has been properly dried, place it in the print frame with the sensitized side and the marks and figures against the glass. Expose the whole strip to the light for one minute; then cover the part of the strip marked 1 with a thin board or anything that will prevent the light from striking the

part covered. At the end of the second minute cover parts 2 and 1; at the end of the third minute, parts 3, 2, and 1,

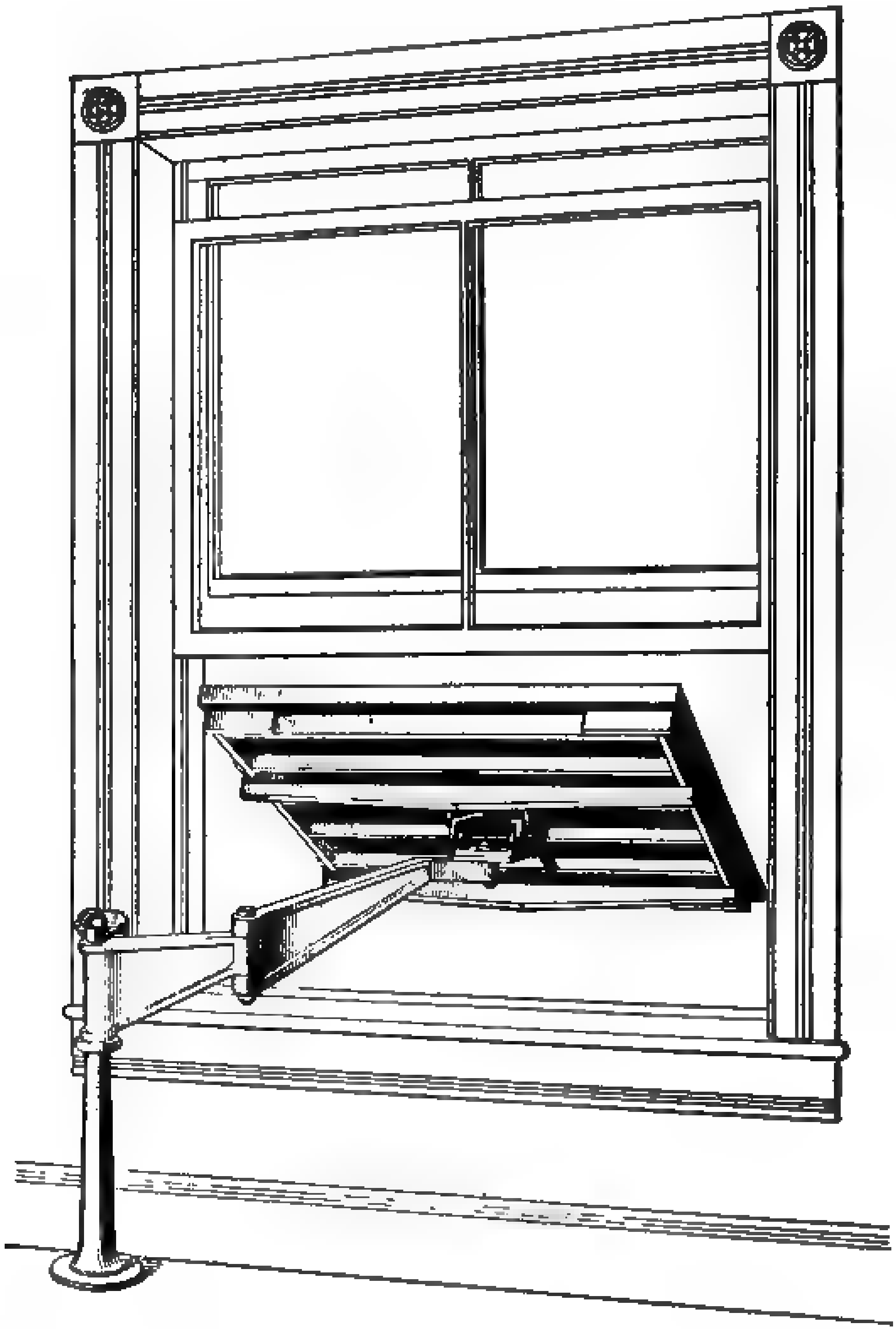


FIG. 8

etc. When twelve minutes are up, part 1 will have been exposed one minute; part 2, two minutes, etc., part 12 having been exposed twelve minutes. Remove the frame to

the dark room, and cut the strip so that it will be divided into two strips of the same length and half the width. Wash one of the strips as before described, and when it has dried, select that shade of blue which suits; notice the number of the part chosen, and it will be the length of time that the print was exposed. Examine carefully the corresponding number on the other strip, and the correct color of the projecting edge of the print beyond the tracing is determined. All prints should be exposed until this color is reached, no matter how long or how short the time may be; then they should be immediately taken out and washed.

Fig. 8 of the text shows a patented frame that can be swung to the outside of the window and adjusted to any angle. When not in use, it can be folded up against the wall, and occupies but a little space. It is made in different sizes, from 16 in. × 24 in. to 48 in. × 72 in. It is one of the best frames in the market, and is placed in such a position relative to the window that the window sash can be lowered to the top of the main arm, to keep out the cold during the winter.

DRAFTING-ROOM PRACTICE

20. The practice in the architectural drafting room is as varied as the individuality of the architect. Many architects, in order to practice economical administration in their offices, make as few drawings as possible, and those that they do make are exceedingly meager in detail and dimensions. On the other hand, the conscientious architect, who bears in mind his client's welfare, furnishes all the necessary drawings required to show every detail of construction. He exercises care in dimensioning his drawings, so that there can be no possible misunderstanding of his intentions by the contractor.

It is the architect of the latter class we desire our students to emulate, and the drawing plates in the course have been laid out so as to inculcate precision and accuracy. They are completely dimensioned in every detail, and though the

student may in practical work learn short-cut methods, he must first understand thoroughly that a drawing to be of use must contain all of the information necessary and required by the contractor in the erection of the structure, the drawings, of course, being supplemented by the stipulations in the specifications.

The work of the practicing architect includes the making of preliminary sketches or studies; working drawings such as plans, elevations, and sections, drawn to a scale of $\frac{1}{8}$ inch or $\frac{1}{4}$ inch to the foot; and detail drawings full size or to a scale of $\frac{3}{4}$ inch or $1\frac{1}{2}$ inches to the foot. Distinct from the work of drafting is the writing of the specifications, the conduct of the business between the owner and the contractor, and the superintendence of the work under construction.

The preliminary drawings or sketches are usually made roughly in pencil, but with an artistic touch, and are often tinted to show the color scheme of the interior and exterior of the building. The working drawings are carefully studied and laid out to meet the requirements of the client. In making these drawings the general construction is decided upon, the walls and foundations proportioned, and the elevations carefully designed. The detail drawings are employed to show the special construction of the steel or wood framing, interior trim and details, or exterior masonry or carved stonework. Besides these the architect often finds it necessary to furnish full-size details on manila paper of window boxes, door frames, and such work as carved-stone or terra-cotta details.

As much of the time the successful architect is devoted to the business part of his work and exercising a supervision over the work in progress in his office, he usually employs a chief draftsman or designer who is a competent architect. Subordinate to this person there may be several draftsmen and one or two students. The larger offices in the great cities have a more complex system, from the fact that they employ from fifty to one hundred people. Where the organization is of this scope, it is usual to subdivide the work and place one building in the hands of a competent designer with a

couple of assistants, it being their duty to devote their sole energies and time to the one structure. This person is directly under the control of the chief of the office. Connected with these large offices are a number of building superintendents whose duties are to inspect the work under way on the various buildings. One inspector would usually be assigned to each large piece of work.

The systematic practicing architect has a uniform style of lettering for all of his drawings, and they are usually titled at the lower right-hand corner. At this position is either printed or stamped the architect's name and the words title, scale, job number, contractor, etc., and after each the necessary information is printed by the draftsman. The drawings are all filed in drawers, either by numbers or alphabetically, so that a particular drawing can be obtained with a minimum loss of time. Where the drawings are numerous it is necessary to have a card index; that is, a system by which the records of the drawings are made upon cards which are systematically filed and cross-indexed. By reference to the cards the number of the drawing is obtained and its place in the files known immediately.

Many architects engage in consultation with a structural engineer when the work requires an expert in steelwork, heavy construction or foundation work. Such services are usually paid for at a stipulated sum agreed upon, which may either be a percentage of the architect's fee or a fixed amount.

It is not unusual for architects to engage in competition for large work. Either in answer to an advertisement or by request, they prepare plans, elevations, and sometimes perspectives of the proposed building. These are submitted on or before a certain date to a judge or committee which adjudicates on the merits of the designs. The judge or committee selects the one which appears the most suitable, and the successful architect is either rewarded by receiving the commission for the execution of the work, or is paid a substantial premium. In order to encourage competition, it is usual in large works to offer three or four prizes, the lowest

of which will at least pay a portion of the expenses the architect has incurred in preparing the drawings. After the selection the drawings are returned to the unsuccessful competitors. It is usual that competitive drawings are required to be submitted in a uniform style of rendering. The usual requirements are that the drawings be of a particular size, that the building shall not exceed in cost a stipulated sum, and that plans, elevations, and perspectives be furnished, consisting of line drawings in ink on white paper and that the windows shall not be blackened, and no wash, color, or shade lines shall be used.

ADVANCED ARCHITECTURAL DRAWING

INTRODUCTION

1. In *Architectural Drawing*, the examples treated in the plates could be executed entirely with the instruments, and consisted of such plans and details as constitute the larger part of architectural office practice.

The subjects treated in this section will consist of architectural features that will involve both freehand and instrumental drawing, giving the student an opportunity of exhibiting the progress he has made in ornamental drawing, and imparting to him a knowledge of the application of ornament in architectural design.

The plates to be drawn from this paper are to be the same size as those of the previous ones, viz., 13 in. × 17 in. inside the border lines. No part of a drawing should be inked in before the whole drawing has been finished in pencil, as was explained in detail in *Geometrical Drawing;* and all the dimensions and dimension lines, as well as the shade lines and headings, should be shown, but the reference letters may be omitted entirely.

THE ORDER

2. An **order** in architecture is the term applied to the system used by the architects of the classic period to proportion the various parts and details of their buildings. There are five of these orders—the Tuscan, Doric, Ionic, Corinthian, and Composite—each of which possesses distinguishing

characteristics of form and proportion, which will be pointed out in the explanation of the following plates, while the complete analysis of the orders and their details will be discussed in *Architectural History and Design.*

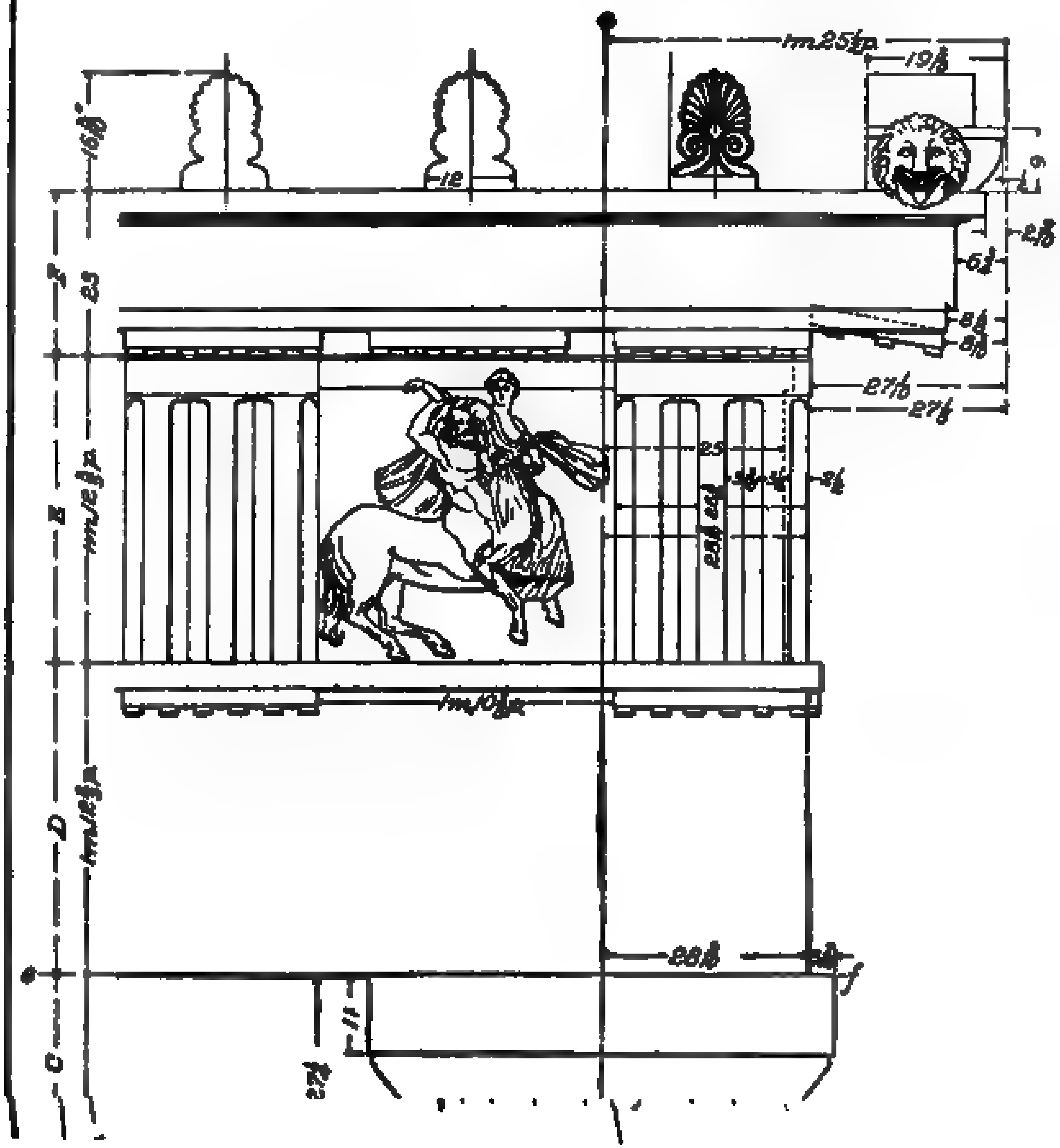
The Doric, Ionic, and Corinthian orders were originated by the Greeks, and the first three of the following eight plates will exhibit the orders in their early Greek form. The next five plates will show the Roman modification of these orders, together with two additional orders, which are of purely Roman invention, namely, the Tuscan and the Composite. These five orders, or systems of proportion, are of the utmost importance to the student, as they furnish him with a set of rules by which he may determine the relations that should exist between certain parts and details of a building. These rules are subject to slight variations in modern works, but are positive so far as their applications to the original orders are concerned.

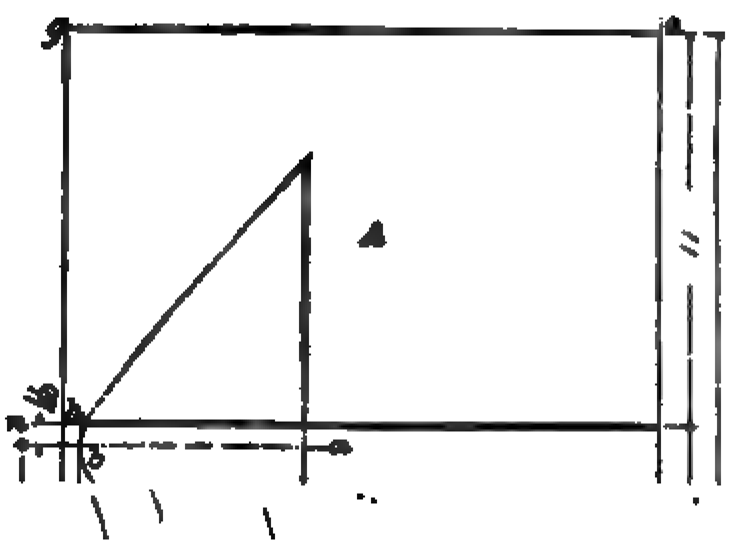
All the orders consist essentially of three principal divisions; namely, the **stylobate,** the **column,** and the **entablature.** The stylobate is that portion of an order which forms the substructure, or foundation on which the column or columns stand, and is usually disposed so as to distribute the load transmitted by the column over a larger area than is represented by the section of the column itself. The column consists of the shaft or pier which supports the superstructure, and is usually possessed of an ornamental **base** and **capital,** which are details that differ widely in the several orders, as will be explained as they are met with in the following exercises. The entablature is the superstructure proper. It consists of three principal divisions, called the **architrave, frieze,** and **cornice,** each of which serves a particular purpose, both structural and ornamental, as explained further on.

As the three Greek orders were the original systems, the student will first make drawings of them, and it is suggested that he pay particular attention to the explanations given in the text, so that the drawing of the subsequent Roman orders and their details may be fully understood.


Fig 4
Fig 1

GRECIAN DORIC.





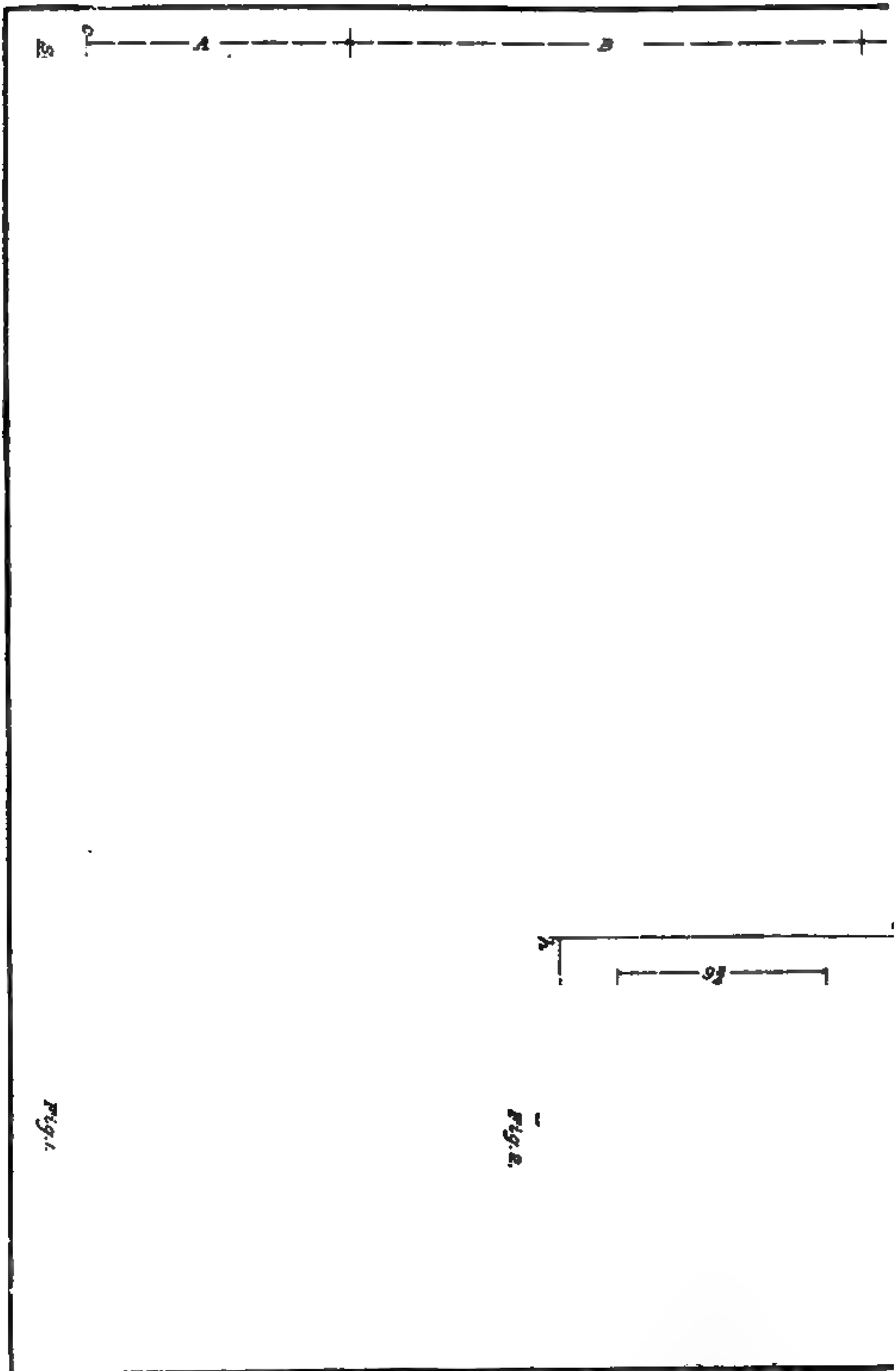
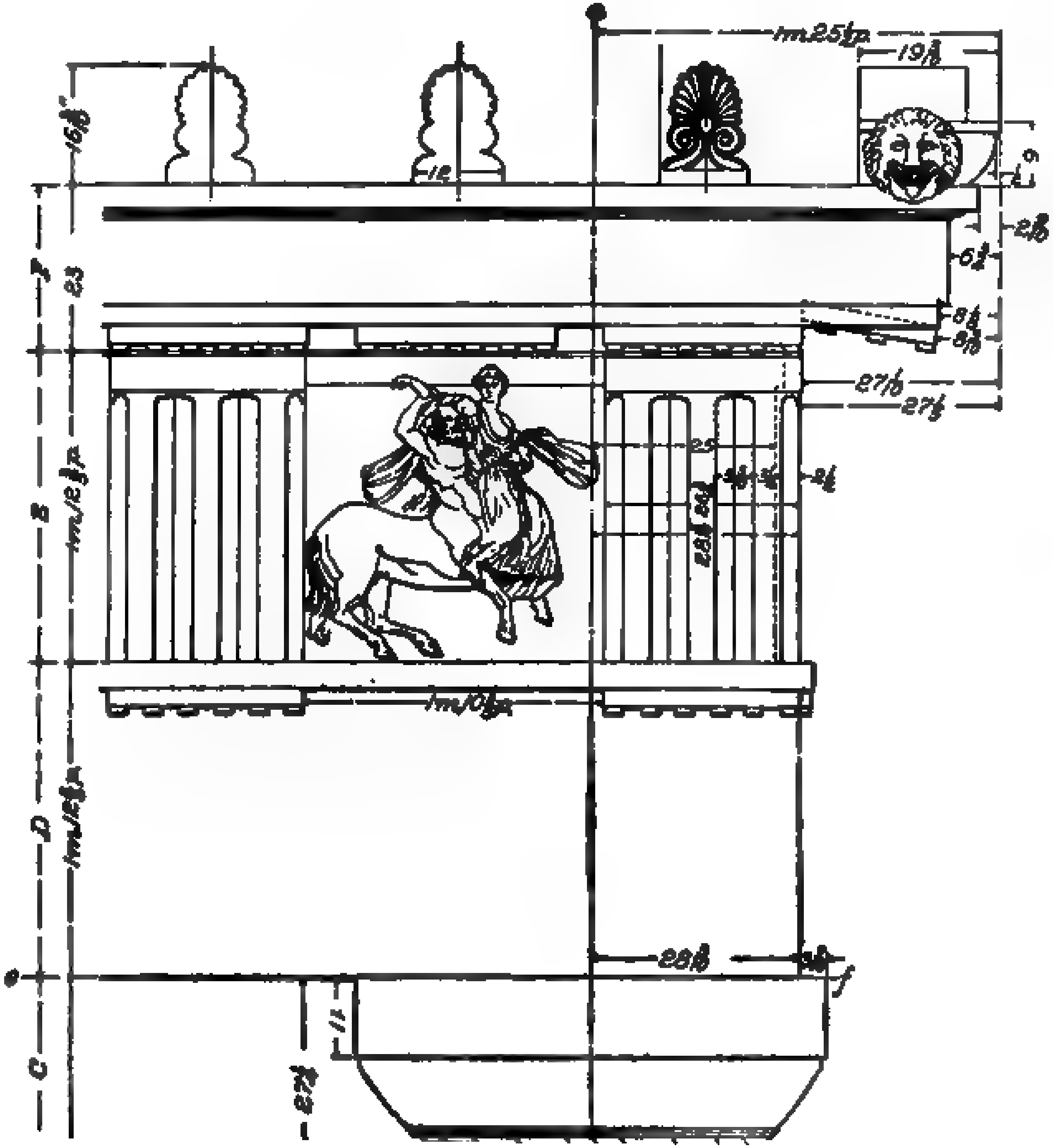
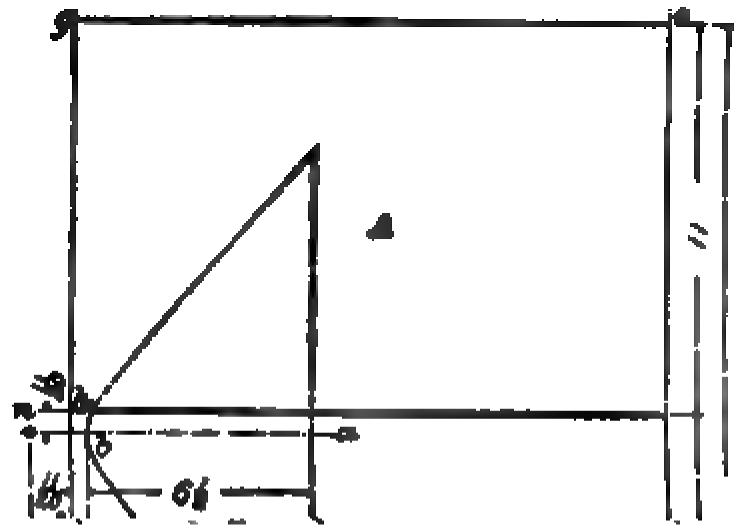


Fig. 1.

Fig. 2.

GRECIAN DORIC.





DRAWING PLATE, TITLE: GRECIAN DORIC

3. The Doric is the most ancient of the three Grecian orders, and represents the system of columnar construction in its simpler form. In Fig. 3 of this plate, *A* shows the stylobate of the order disposed in three equal steps, so as to spread the foundation area of the structure. *B* is the shaft of the column, and *C* is the capital. (The Grecian-Doric column has no base.) *D* is the architrave, which consisted in the early Greek structures of a number of lintels or stone beams, extending from the top of one column to the top of the next. *E* is the frieze, which was occupied by a number of stone ceiling beams or flat slabs, which rested their ends on the lintels of the architraves and formed the direct ceiling on the inside of the structure. *F*, the cornice, was the roof construction proper, and consisted of stone details built above the frieze to cover the ends of the roof beams and to provide a suitable finish to the eaves. The general effect of these details, when assembled in the complete order, is shown in the perspective sketch, Fig. 1, of the text.

The column of the order shown in this plate is 24 inches in diameter, and is drawn to a scale of 1½ inches = 1 foot, as are all of the following plates of the orders; but the 1½-inch scale is not used to proportion the various details, as the diameter of the column is the governing measurement, and in architectural orders the members are proportioned in their ratio to the diameter of the column, according to an arbitrary scale of **modules** and **parts**, as explained further on.

The term *module* is a diminutive of the Latin *modus*, meaning "a measure"; and in the architectural orders the module is in nearly all cases equal to one-half of the diameter of the column. The diameter of the column in this plate being 24 inches, the module is 12 inches. The module is divided into 30 subdivisions, called *parts*, and a dimension of 2 modules and 15 parts would, on this plate, be equivalent to 2 feet 6 inches. In the following descriptions of the orders, the terms "modules" and "parts" will be abbreviated to "m." and "p.," in order that the text may correspond

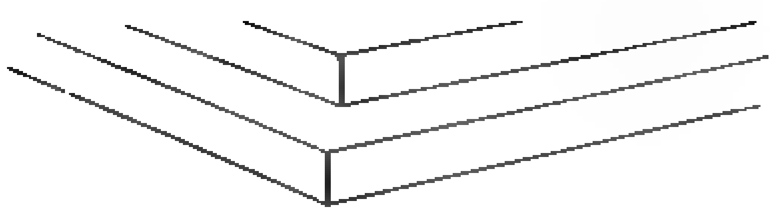


Fig. 1

more closely with the expressed measurements on the drawing plate, and that there may be no confusion with regard to the word "parts" when it is used in a more general sense. Begin this plate by constructing a scale of modules as shown. Draw a line 6 inches in length and $\frac{5}{8}$ inch above the lower border line. Divide this line into 4 equal parts of 1 m. each, and subdivide the first part into 30 p., as shown. Now draw Fig. 1, which is a plan of the column and stylobate; locate the lines of the upper step, each $\frac{1}{2}$ inch from, and parallel to, the border lines; draw *a b* and *c d*, the axial lines of the plan of the column, each at a distance of 1 m. 2 p. from the lines of the upper step of the stylobate, and on their point of intersection as a center, and with a radius of 1 m., draw a circle defining the circumference of the shaft. The surface of the shaft is grooved perpendicularly by the 20 flutes, or channels, each of which is cut to an elliptical curve, as shown in the plan. The plan of the column must therefore be divided into 20 equal parts, by lines radiating from its center. Each pair of these lines will embrace $\frac{1}{20}$ of the circumference of the circle defining the plan of the column, or 18°, and the lines will pass through the **arrises**, or sharp edges projecting between the flutes.

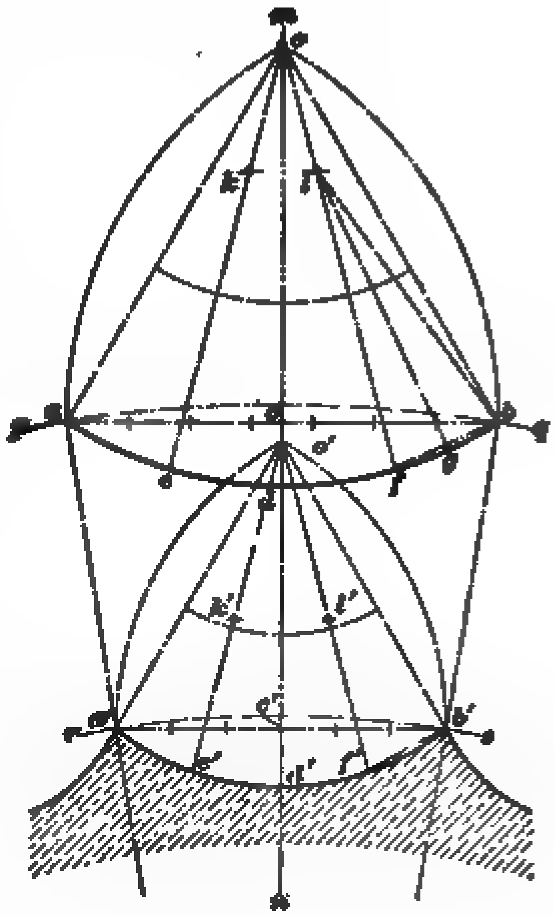


Fig. 2

Before drawing these elliptical flutes in the plan of the column, the student should draw, on a separate piece of paper, Fig. 2 in the text, which is an enlarged plan of one of the flutes, showing the method of striking its curve. At *a d b* of Fig. 2 is shown the form of the channel at the bottom

of the shaft; and at $a'd''b'$, the form of the same channel at the necking. Let pq and rs be the arcs of the lower and upper sections of the shaft, respectively, and lay off accurately ab and $a'b'$ equal to $\frac{1}{16}$ of the circumference. Draw the chords ab and $a'b'$ and the center line mn, cutting the chords ab and $a'b'$ at c and c'. For the depth cd of the channel at the base, divide ab into 7 equal parts, and make cd equal to one of these parts; for the depth $c'd''$ at the necking, divide $a'b'$ into 6 equal parts, and make $c'd''$ equal to one of these parts. The depth of the channel at the necking is therefore greater, in proportion to its width, than at the bottom of the shaft. To find the centers of the three arcs that compose the curve adb, construct, upon ab as a base, the equilateral triangle aob, and bisect the angles aod and dob by the lines oe and of. The point o will then be the center of the arc edf. Join fb, and at its middle point g erect a perpendicular gl, cutting of at l; the point l is the center for the arc fgb; the center k of the arc ae is similarly found. The centers o', k', l' for the arc $a'd''b'$ are determined in precisely the same manner as described for the arc adb.

Now draw Fig. 3, locating the center line ab $4\frac{1}{2}$ inches from, and parallel to, the left-hand border line; and at right angles to ab draw cd, the bottom line of the stylobate, $\frac{3}{4}$ inch above the lower border line; then lay off from cd, on ab, the measurements of the principal divisions of the order, and draw horizontal lines defining these divisions. Lay off each side of ab, on the top step of the stylobate, 1 m., and dot the perpendicular lines defining the extreme diameter of the column, as shown. On the lower line of the architrave D, lay off each side of ab 32 p., and draw perpendicular lines down from the bottom of the architrave, till they intersect with a horizontal line drawn 11 p. below. These will define the elevation of the **abacus**, or square block on the top of the capital of the column. The diameter of the column is less at the top than at the bottom, and the sides of the column are curved in profile from the base to the neck of the capital; but, as the full length of the column is not shown, the method of profiling this curved outline will

not be described at present. When the drawing of the Roman orders is explained, this curved outline of the shaft will be discussed, and the method of describing it will be shown in detail. Draw the outside, or return, lines of the architrave and frieze 28$\frac{5}{16}$ p. to the right of the center line *a b*. Then, 26$\frac{3}{4}$ p. from the return line of the frieze, draw the perpendicular line defining the width of the **triglyph**, which is the ornamental block set in the frieze over each column and over each space between the columns. The triglyphs, in the early construction, consisted of the ends of the ceiling beams which rested on the architrave. Draw this triglyph at the extremity of the frieze according to the measurements given, and duplicate it as shown, 1 m. 10$\frac{3}{4}$ p. to the left. The space between two triglyphs is called a **metope**, and in nearly all examples of Greek architecture the metopes are filled with a carved slab. Immediately over the triglyphs and metopes are the **mutules**, with six little drops, or **guttæ**, as they are called, on the under side. The mutules are not level on the soffit, but pitch upwards, as seen on the return of the cornice, where the mutule is shown in side elevation. These mutules represent the under side of the slanting roof beams as they existed in the early wood construction, and the guttæ are derived from the wooden treenails, or pins, which held these members in place. Draw the **corona**, which is the broad band of the cornice, and above it draw the molding, and also the palmettes which are centered over each mutule. Draw the lion head and echinus at the return line, carefully following the measurements given on the drawing plate.

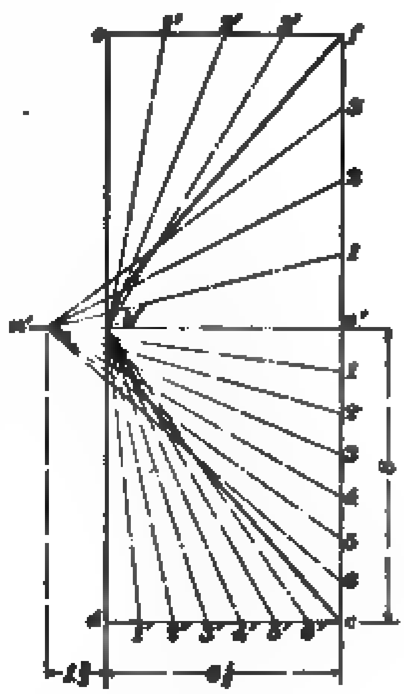


FIG. 3

Now draw Fig. 2, which is an elevation of the details of the capital, four times the scale of Fig. 3. Draw *e f* in line with the right-hand side of the stybolate in Fig. 1, and locate *g e*, the

upper line of the abacus, $11\frac{1}{4}$ inches above the lower border line. Draw the abacus 11 p. deep. Before profiling the echinus B and the curve of the shaft at D, both of which are arcs of hyperbolas, the student should give his attention to Fig. 3 in the text, which is a method of describing a hyperbolic curve.

Lay off $a' b'$ 6 p. long, and upon $a' b'$ as an axis, construct the rectangle $c d e f$, marking off $a' c$ 8 p. long. Produce $a' b'$ to n', making $b' n'$ $1\frac{3}{8}$ p. long. Divide $a' c$ and $a' f$ into any convenient number of equal parts, as at *1*, *2*, *3*, etc., and divide $c d$ and $f e$ into the same number of equal parts, as at *1'*, *2'*, *3'*, etc. Join n' *1* and b' *1'*, and their intersection will be a point of the required curve. Other points in the curve of the hyperbola are similarly found, by drawing the intersecting lines n' *2*, b' *2'*; n' *3*, b' *3'*, etc.

To draw the curve at $C D$, Fig. 2, construct the rectangle $c' d' e' f'$ in its oblique position, according to the measurements given, and inscribe the hyperbola according to the method above described.

The dotted line of this second curve shows the profile of the curve of the neck before the cutting of the channels; or, what is the same thing, the dotted line $C D$, with its downward continuation E, gives the true profile of the shaft on an axis passing through two opposite arrises, or edges, between the channels. The straight portion of this line at E shows, therefore, the extreme size of the shaft at the necking, and from it the various projections are figured.

As may be seen, part of the hyperbola last drawn determines the projection of the outer faces of the **annulets,** or rings, around the neck of the capital at C. These annulets should project about $\frac{1}{4}$ p. from the surface of the echinus; hence this projection, or the distance between the two hyperbolic curves at C, will form a check upon the accuracy of the drawing.

The full-line profile, just within the dotted line $c d e$, is the projection of the edges, or arrises, of the channel whose center is upon the axis $c d$ of Fig. 1, parallel to the face of the abacus.

The distance between the real and projected profile lines just considered is represented, in Fig. 2 of the text, by the distance between the *arc a′ b′* and the *chord a′ c′ b′*. The inner dotted line, passing near the point *e* on Fig. 2 of drawing plate, gives the depth of the channel at its center; this depth is likewise represented, in Fig. 2 of text, by the distance *c′ d′*.

Now complete the capital of the column in Fig. 3, drawing the echinus according to the method described for Fig. 2; then draw Fig. 4, which is a half plan of the under side of the capital. Locate the center line *g h* $4\frac{7}{8}$ inches above the lower border line; draw the flutes as shown, describing their curves from centers found according to the methods explained for Fig. 2 in the text. Project the lines of these flutes to the upper part of the column in Fig. 3, and project the lines of the flutes in Fig. 1 to the center line *c d*, from which their spacing may be marked on a strip of paper and transferred to the lower part of the column in Fig. 3. Now finish Fig. 3 entirely, and commence Fig. 5, which is a section through the frieze looking upwards, showing the soffit of the corona; draw the axial lines *a b* and *c d* $3\frac{1}{2}$ inches and 4 inches, respectively, from the border lines; mark points locating, and draw lines defining, the various members of the corona, according to the measurements given in Fig. 3; then locate and draw the triglyphs and guttæ, and draw the anthemion ornament and lion head freehand.

DRAWING PLATE, TITLE: GRECIAN IONIC

4. In this plate, showing the details of the Grecian-Ionic order, the stylobate is shown at *A*; the base, shaft, and capital of the column at *B*, *C*, and *D*, respectively; and the architrave, frieze, and cornice of the entablature at *E*, *F*, and *G*. A perspective view of the order is shown in Fig. 4 of the text.

The scale to which this plate is to be drawn is the same as for the previous plate, viz., $1\frac{1}{2}$ inches = 1 foot, but the column being but $22\frac{1}{2}$ inches in diameter, the module will be only $11\frac{1}{4}$ inches. Construct a scale of modules on a line $\frac{3}{8}$ inch

above, and parallel to, the lower border line, making it 4 m. in length, and dividing the first module into 30 p., as was done on the previous plate. Now draw the center line *a b* at a distance of $4\frac{3}{16}$ inches from, and parallel to, the left-hand border line, and draw the lower line of the stylobate *c d*, $\frac{3}{4}$ inch above the lower border and at right angles to the line *a b*; draw *e f*, the bed line of the architrave, $9\frac{3}{8}$ inches above the lower border line.

On the center line *a b* lay off a number of points from the measurements given, locating the position of the horizontal lines of the base, capital, and entablature; locate the centers of the arcs, and profile the moldings of the base, omitting for the present the fluting of the shaft, though the sides and *apophyge* may be shown. **Apophyge** is the term given to the curved expansion from the side of the column where it joins the base, as shown at *k*. Now proceed with the entablature, drawing the three facias of the architrave and the moldings crowning them—carefully profiling these moldings according to the

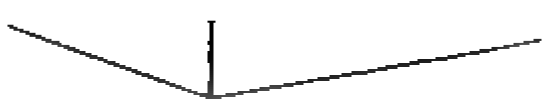


Fig. 4

GRECIAN IONIC.

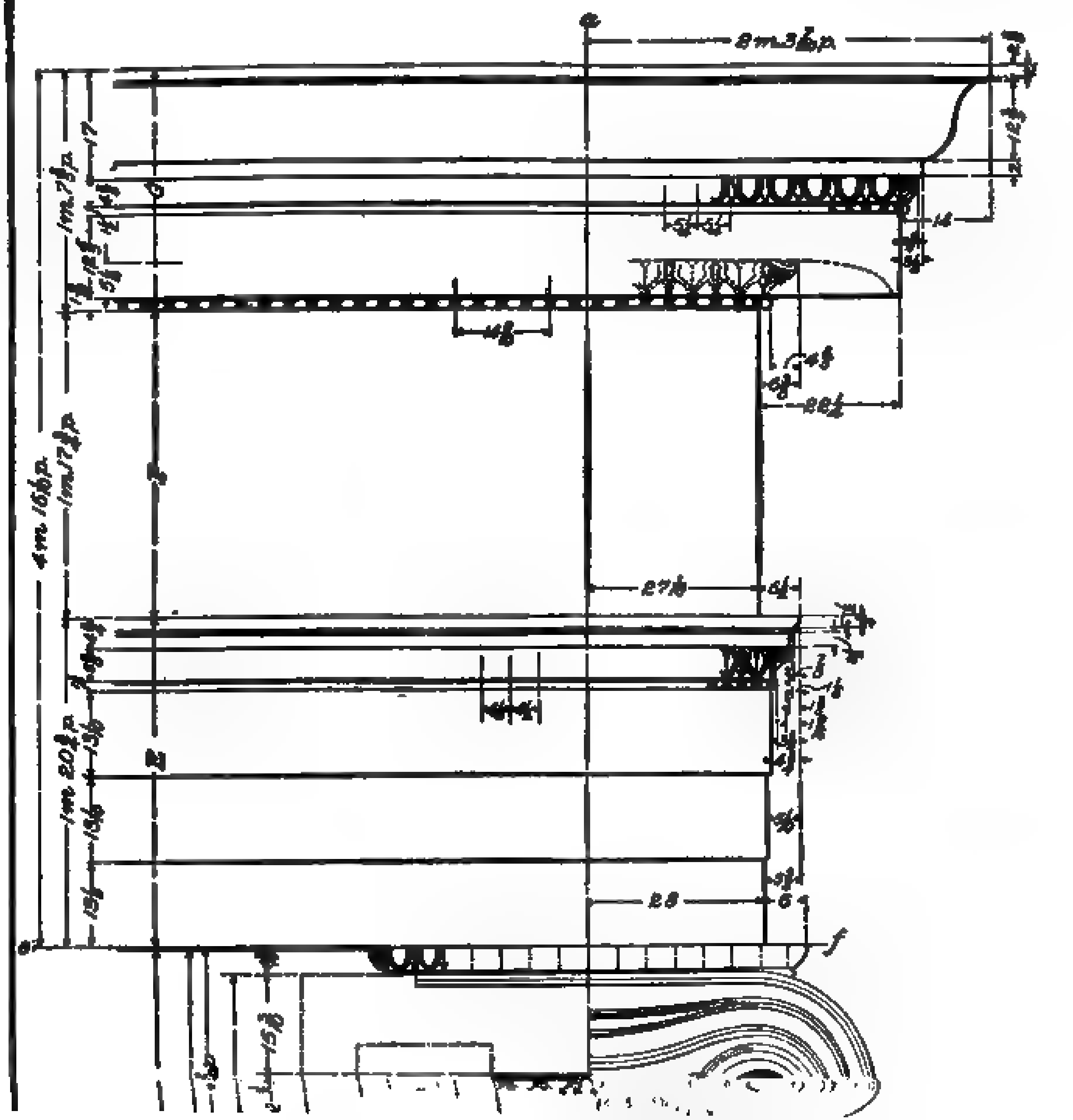


Fig. 2

measurements given, but omitting, for the present, the ornament on the cyma reversa. The frieze in this order, it will be observed, is a plain band, devoid of any triglyphs or metopes, as in the Doric, while the corona consists of a group of simple moldings, elaborated with surface ornament. Carefully draw these details, profiling their outline where they project at the return of the entablature, but omitting the ornament until the outlines of the other figures on the plate are complete.

The capital *D* is the most complicated feature of the Ionic order. It consists essentially of a contracted echinus and a

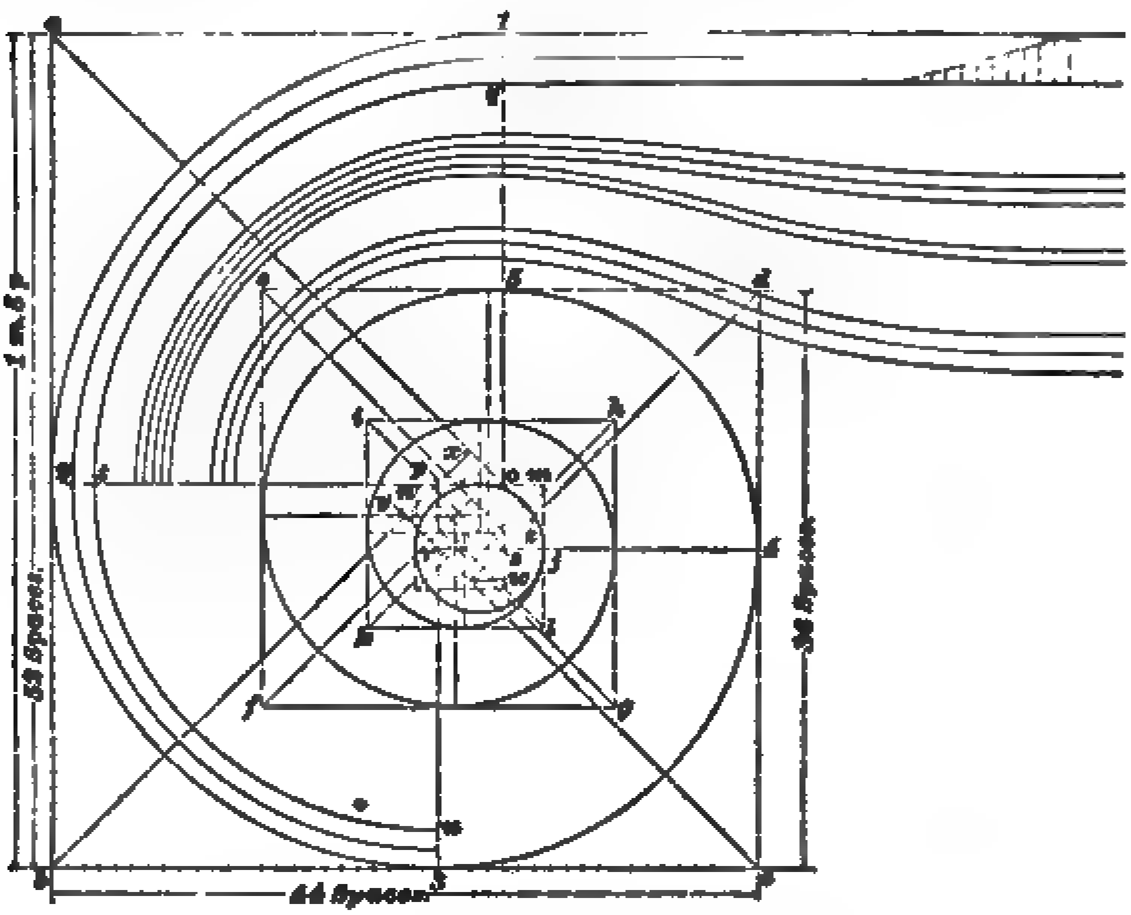


FIG. 5

small torus, over which the *volutes*, or spirals, are turned, forming the distinctive characteristic of the order. A necking under the capital, which is usually decorated with carved ornament, is separated from the shaft of the column by a narrow fillet, or bead molding, called the *astragal*. Before drawing the capital, the student should practice the volute on a separate piece of paper until he becomes familiar with the

mathematical system of its lines. In Art. **14**, *Ornamental Drawing*, a method of laying out the construction lines for the volute is given, the curve being drawn freehand. In Fig. 5 of the text, the lines *a b*, *b c*, and *c d* are laid off in the proportion of 6½ to 5½ to 4½, and for the convenience of this proportion *a b* is divided into 52 equal parts; *b c* will then be 44 of these parts, and *c d* 36 parts in length. The lines *d e*, *e f*, *f g*, *g h*, etc. are all laid off in the same manner as were corresponding lines of the volute described in Art. **14**, which gives *d e* 31 parts; *e f*, 26 parts; *f g*, 22 parts; *g h*, 18 parts; etc. *a z* is then drawn at an angle of 45° with *a b*, and *b x*, *c y*, and *d w* are also drawn, each at an angle of 45° with the line from whose extremity it starts. The intersections of these four lines will form a square *w y x z*. The line *x z* is then bisected at *o*, and the arc *1–2* is drawn with the radius *o 1*. The line *x y* is then bisected at *p*, and the arc *2–3* is described with the radius *p 2*. The lines *y w* and *w z* are then bisected in *r* and *s*, and the arcs *3–4* and *4–5* are described in the radii *r 3* and *s 4*. This completes the first convolution of the spiral.

The second convolution is described in precisely the same manner, by forming another square at the intersection of the four lines drawn at an angle of 45° from *e*, *f*, *g*, and *h*, and the third and last convolution is described from the square formed at the center, by lines drawn at 45° from *i*, *k*, *l*, and *m*. The radius of the *eye*, or central disk, is then obtained by dividing the distance from the finish of the last arc at *j* to the point *1*, the start of the first arc, into 8 equal parts. With one of these parts as a radius, and with a center on the line *r j*, a circle is then drawn which is tangent to the last arc at *j*.

The bands *q* are drawn by setting off their dimensions on the line *o 1* as at *q 1* and dividing the distance *q 1* into 11 equal parts. The width of the band at *2* will be 10 of these parts, and at *3* it will be 9 parts, and so on all the way round until the bands become tangent at *j*. To draw the bands, place one leg of the compass at *o* and set the pencil point for the radius *o q*; then, with a center on the line *o t*, and a

radius *o q*, describe the quadrant *q t*; then, with a center on the line *p u*, and a radius *p t*, describe the arc *t u*, and so on to the completion of the bands.

Having drawn the volute on a separate sheet of paper, and to a large scale, proceed to draw it on the plate. Lay off below *e f* $4\frac{3}{10}$ p. for the thickness of the abacus, and draw a horizontal line; perpendicular to this line, and $44\frac{3}{8}$ p. from the center line *a b*, draw the first construction line of the volute 35 p. in length. Then proportion the lines in the ratio of $6\frac{1}{2}$ to $5\frac{1}{2}$ to $4\frac{1}{2}$, which will make the first three approximately 35 p., 30 p., and 24 p.; and, proceeding as described for Fig. 5, complete the construction lines of the volute, on both sides of *a b*. Then draw in, on the right-hand side, the curves of the volute and its bands.

Where these bands dip down at the center of the capital, a number of points should be laid off according to the scale of modules, and the curves first sketched freehand and afterwards strengthened with the irregular curve. The egg-and-dart ornament on the echinus, and the guilloche on the torus, may now be drawn in between the volutes, and the egg-and-dart on the echinus and water-leaf ornament on the cymas of the entablature. The cyma reversa, shown in *dotted lines* under the corona of the cornice, is so drawn because it is *undercut*, or recessed, behind the lower face of the corona, and is therefore not seen on the elevation of the order, though it appears in the perspective, Fig. 4, as the view of the cornice is there taken from below. Now proceed with Fig. 2, which is a half plan of the column, looking upwards. Draw *i j* at right angles to *a b*, and $4\frac{5}{16}$ inches above the lower border line. With a center on the point of intersection of *i j* and *a b*, and with a radius of 25 p., draw a semicircle, as shown. Divide the circumference of this semicircle into 12 equal parts, and on each of these points of division as a center, and with a radius of $2\frac{5}{8}$ p., describe a semicircle, which will be the plan of the flutes, while the spaces between these semicircles, where they intersect the circumference of the shaft, will be the fillets between the flutes. Now project the lines of these flutes to the elevation

of the capital and neck of the column, and draw their semicircular finish against the fillet under the column neck. To draw the flutes on the section of the shaft immediately over the base, it will be necessary first to draw Fig. 6, which is a half plan of the column and base. Draw the line *c d* 3 inches above, and parallel to, the lower border line, and at right angles to *c d* draw *a b* 2¾ inches from the right-hand border line. On the intersection of *a b* and *c d* as a center, and with a radius of 1 m., draw the semicircular outline of the column; divide the circumference of this semicircle into 12 equal parts, and with the points of these divisions as centers, and a radius of 3½ p., draw the semicircular flutes and the fillets between them. Then draw the plan of the moldings according to the measurements given in Fig. 1, and the plan of the stylobate, which extends 3½ p. beyond the lower torus of the base. Project the lines of the flutes and fillets to *c d*, and transfer their position to the lower section of the column in Fig. 1. Now complete the flutes and fillets in Fig. 1, drawing their finish on the apophyge of the shaft, partly with the bow-pencil and partly freehand, as the case may require. Return to Fig. 2, and draw the under side of the capital as shown. The portions of the volutes seen in the elevation are here observed to be but 2½ p. in thickness, while the material behind the volute is hollowed out towards the shaft, and is ornamented with rows of bead molding and fillets. This portion of the capital is called the *bolster*, and its appearance in section, on the line *i j*, may be seen in Fig. 4, while a section through the capital between the volutes on the line *a b* is shown in Fig. 5.

Now draw Fig. 3, which is a side elevation of the capital, showing the bolster. Draw the center line *a b* at a distance of $2\frac{5}{16}$ inches from, and parallel to, the right-hand border line. Project from Fig. 1 the horizontal lines of the abacus, and the locations of the small torus, echinus, and fillet of the capital, which show on the front elevation between the volutes. Project also the lines defining the depth of the volutes and the fillet immediately under the bead molding. On this

fillet line lay off, on each side of the center line *a b*, a distance of 24 p., and on *a b* each side of the fillet line lay off $7\frac{1}{2}$ p.; then construct an ellipse 48 p. long and 15 p. wide, as shown. This ellipse will define the outline of the bottom of the bolster. Draw the bead moldings on the bolster according to the measurements given in Fig. 2, and complete the figure.

Now draw Figs. 4 and 5. The lines defining the depths of the members on Fig. 4 should be projected from Figs. 1 and 2, and the projection of these members from the center of the column may be obtained from Fig. 2. The face line of the column is shown in Fig. 4 at *k' l'*, and in Fig. 5 at *k l*. The heights of the moldings on this line may be scaled from Fig. 1 or transferred by means of a strip of paper. The projection of the abacus, torus, and echinus may be obtained from Fig 3, but the other details should be scaled from the figure itself.

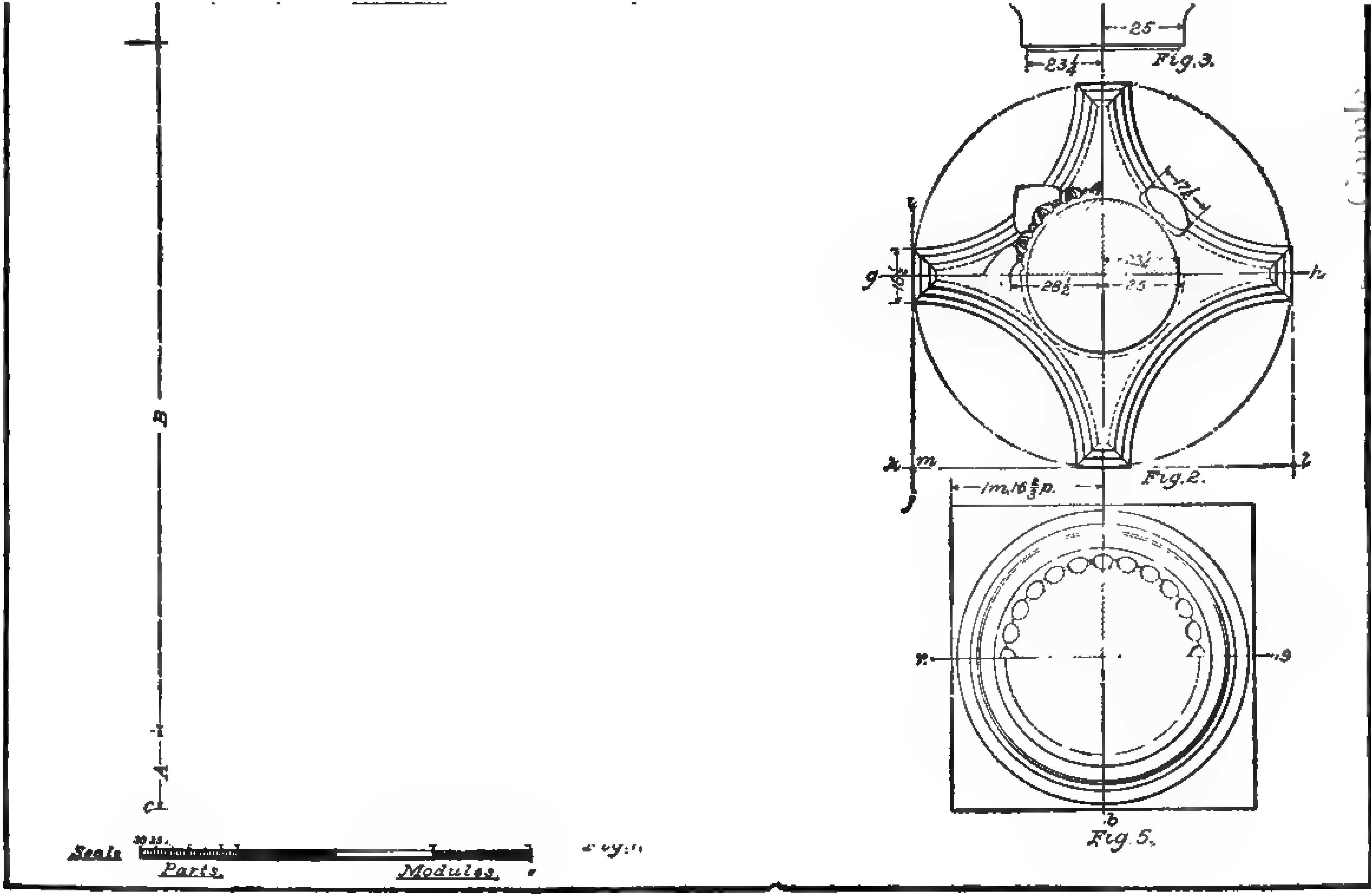
Now draw Fig. 7, which is a plan of the under side of the entablature, looking upwards from a section line through the frieze. Draw the center line *a b* at a distance of $3\frac{11}{16}$ inches from the right-hand border line, and at right angles to *a b* draw *c d* $4\frac{3}{16}$ inches from the upper border line. With the point of intersection of these lines as a center, and with a radius of 25 p., draw a circle, which will be the plan of the top of the shaft of the column; then measure off on *a b* $27\frac{1}{16}$ p. above *c d*, and measure off on *c d* $27\frac{1}{16}$ p. to the right of *a b*; through the points so located draw a horizontal and a vertical line to define the projection of the frieze. Then, from the frieze line measure off the projections of the various members of the cornice, and draw lines defining these members. Draw the miter lines where the cornice members intersect at the angle, and complete the figure.

Now proceed to draw the ornamentation of the moldings of all the figures, cross-hatch the parts shown in section, and complete the plate, carefully inserting all the dimensions, but omitting all the reference letters, except those shown in capitals, which refer to the main subdivisions of the order.

DRAWING PLATE, TITLE: GRECIAN CORINTHIAN

5. On this plate the stylobate is omitted, and *A*, *B*, and *C* show the base, shaft, and capital of the column, while *D*, *E*, and *F* are the architrave, frieze, and cornice of the entablature. The plate is to be drawn to a scale of $1\frac{1}{2}$ inches = 1 foot, and the diameter of the column being 15 inches, the module is consequently $7\frac{1}{2}$ inches in length. The column is much more slender than the Doric or Ionic, and the capital is higher and more richly ornamented, as may be seen in Fig. 6 of the text, though the entablature is but slightly modified from the Ionic. Construct a scale of modules, as shown on the plate, locating it $\frac{5}{16}$ inch above the lower border line, and $1\frac{1}{4}$ inches from the left-hand border line. Commence Fig. 1, the elevation of the order, by drawing the center line $a\,b$ at a distance of $4\frac{1}{8}$ inches from, and parallel to, the left-hand border line. Draw the lower side of the base $c\,d$ $\frac{3}{4}$ inch, and the under side of the architrave $e\,f$ $10\frac{5}{8}$ inches, above the lower border line. On the center line $a\,b$ lay off a series of measurements locating the principal divisions of the column and entablature, and draw the horizontal lines defining them. Profile the moldings of the base according to the measurements given, and draw the side lines of the shaft, but omit for the present the fluting of the shaft. Draw the abacus of the capital and the three facias of the architrave, observing that the facias do not lie in perpendicular planes, but incline towards the interior, so that the outer edge of each is on the same perpendicular line as the one next above or below. Omit for the present the carving on the frieze, but draw the moldings over the frieze and locate the dentils in the cornice according to the measurements given. Over the dentil course is a cyma, and above this the corona; draw the echinus and fillet above the corona, and locate the antefixa and cresting which crown the entablature.

Now draw Fig. 2, which is a plan of the capital looking upwards. Draw the center line $a\,b$ (which is common to Figs. 2, 3, and 5) at a distance of $2\frac{1}{2}$ inches from, and parallel


A
B
C
25
23¼
Fig. 3.
7½
23¼
g
16½
28½
25
h
k
m
l
Fig. 2.
1m, 16⅔ p.
b
Fig. 5.
Scale
Parts.
Modules.

to, the right-hand border line, and draw $g\,h$ $5\frac{13}{16}$ inches above the lower border line. From the point of intersection of these lines, and with a radius of $23\frac{1}{4}$ p., draw the circular outline of the bell of the capital, as it would appear in section, at the top of the first row of leaves; and, with a radius of 1 m. $28\frac{1}{2}$ p., draw a circle limiting the projection of the angles of the abacus. From the intersection of this circle with the axial lines $a\,b$ and $g\,h$, lay off the width of the projecting angles, and draw $i\,j$ and $k\,l$ tangent to the circle at its intersections with the axial lines. Then $i\,j$ and $k\,l$ will intersect at m. Now, with m as a center, and a radius of 1 m. $20\frac{1}{4}$ p., describe an arc, which will be one of the sides of the abacus, between the angles. Draw this arc on the four sides, and then increase the radius and draw the arcs of the moldings of the abacus. Locate on the concave sides the block outline of the ornament on the abacus, which is shown in the *elevation*, Fig. 1, to the left of the center line $a\,b$. It will be observed that, while the abacus in the Doric order is simply a square slab, and in the Ionic order a slab with

FIG. 6

molded edges. in the Corinthian order it is deeply hollowed and molded on its sides, and its angles are cut off on straight lines at right angles to the axes.

To draw Fig. 3, which is an elevation of the capital, from an angular point of view, project the horizontal lines of the abacus from Fig. 1, and its breadth across the angles, from Fig. 2. Draw in the leaves and ornament from the dimensions given. The foliated ornament on the Corinthian capital consists of a number of *caulis*, or husks, out of which the *cauliculi*, or twisted stems, spring, forming small spirals or volutes at the sides and angles of the abacus. The body of the capital on which this foliage is arranged is called the *bell*, or core. Now proceed with Fig. 4, which is a plan of the capital similar to Fig. 2, but taken as it would appear from a section through the shaft of the column, and placed in the position that it bears to the elevation in Fig. 1. Draw twenty-four semicircular flutes in this plan, leaving a fillet between each pair of flutes, equal to one-fourth the width of the flute, and project the lines of these flutes and fillets to Fig. 1, as shown. It will be observed that the flutes and fillets terminate in leaf forms where they join the capital, and that the central vein of each leaf is the termination of the fillet; also, that between each pair of leaves another vein extends down into the flute itself. Draw these veins in the flutes shown in Fig. 4, and also the projection of the leaves over the edges of the fillets.

Now finish the foliage in the capital, Fig. 1, laying out the design in a set of squares if desired, and drawing the leafwork freehand. Draw the plan of the base as shown in Fig. 5, locating the line $r\,s$ $2\frac{3}{16}$ inches above the lower border line. On the intersection of $a\,b$ and $r\,s$ as a center, and with a radius of 1 in., draw the circular outline of the shaft, and divide it into 24 parts, each of which will include one flute and one fillet. Draw twelve of these flutes and fillets, and with a strip of paper transfer their projection to Fig. 1; then draw the elevation of the flutes on the lower part of the column. Draw the circular outlines of the base moldings in Fig. 5, from the measurements given in Fig. 1, and the square plinth under

the base, which is 1½ p. wider on each side than the lower torus of the base.

Draw Fig. 6, locating the line *a b* 3¼ inches from the right-hand border line, and *c d* 3¾ inches from the upper border line. With the intersection of these lines as a center, and with a radius of 25 p., draw the circular outline of the top of the column. Draw the extreme lines of the projection of the cornice, 2 m. 21 p. from the center lines, and locate the other members of the cornice from the dimensions given in Fig. 1.

Draw the carved ornament on the frieze in Fig. 1, by a system of squares, cross-hatch all parts shown in section, draw the dimension lines and put in the dimensions, and complete the plate as shown.

DRAWING PLATE, TITLE: TUSCAN ORDER

6. This plate shows the elevation and details of the first of the Roman orders. There are five of these orders, and, although they vary materially from their Greek prototypes, they are similar to them in their principal characteristics. The Tuscan order, a perspective view of which is shown in Fig. 7 of the text, is the simplest of the five, and was probably, in its original form, an imitation of the Greek Doric. With the exception of the Tuscan, the Roman orders are all much more elaborate than those of the Greeks, and in all five we find the stylobate supplanted by a regularly designed pedestal on which the column stands. The moldings of the Roman orders are always profiled with the arcs of circles, while the Greeks usually molded their sections to the arc of a parabola or hyperbola. Other modifications exist in each order, which will be pointed out as they appear in the following plates. The following five plates are all drawn to a scale of 1½ inches = 1 foot, but, as the diameters of the columns differ, the lengths of the modules differ correspondingly, and a separate scale must be prepared for each plate.

In the Roman orders, the pedestal is always one-third, and the entablature one-fourth, the height of the column;

but the proportions of the details of these main divisions are subject to wide variations in the different orders. In each of the following five plates, the pedestal is shown at *A B C*, where *A* is the base, *B* the die, or body, and *C* is the cornice of the pedestal. *D*, *E*, and *F* show the base, shaft, and capital of the column, and *G*, *H*, and *I* indicate the architrave, frieze, and cornice of the entablature.

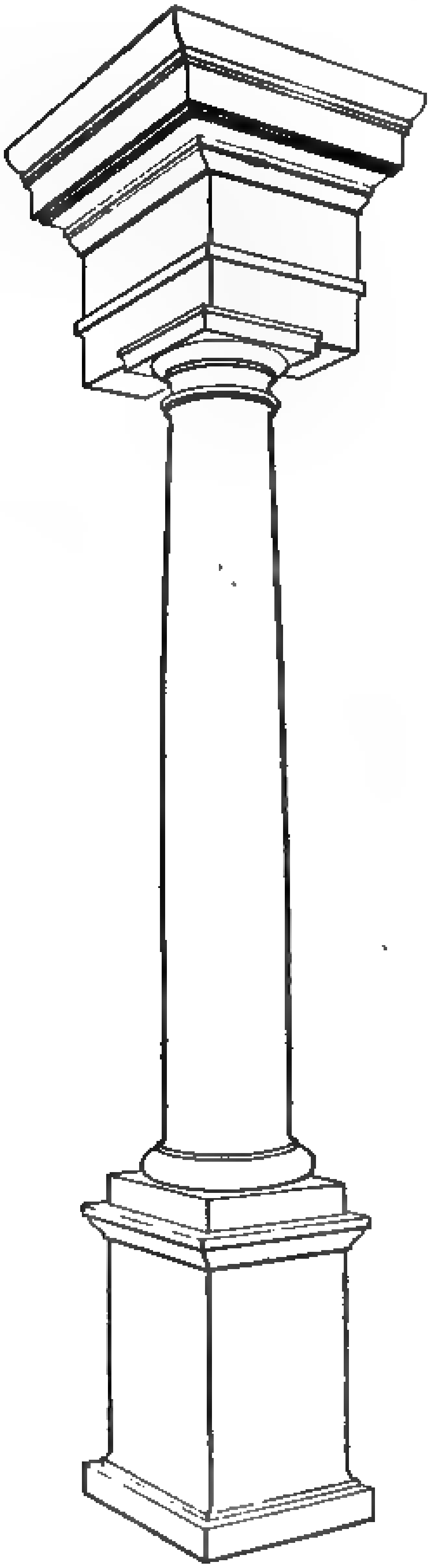
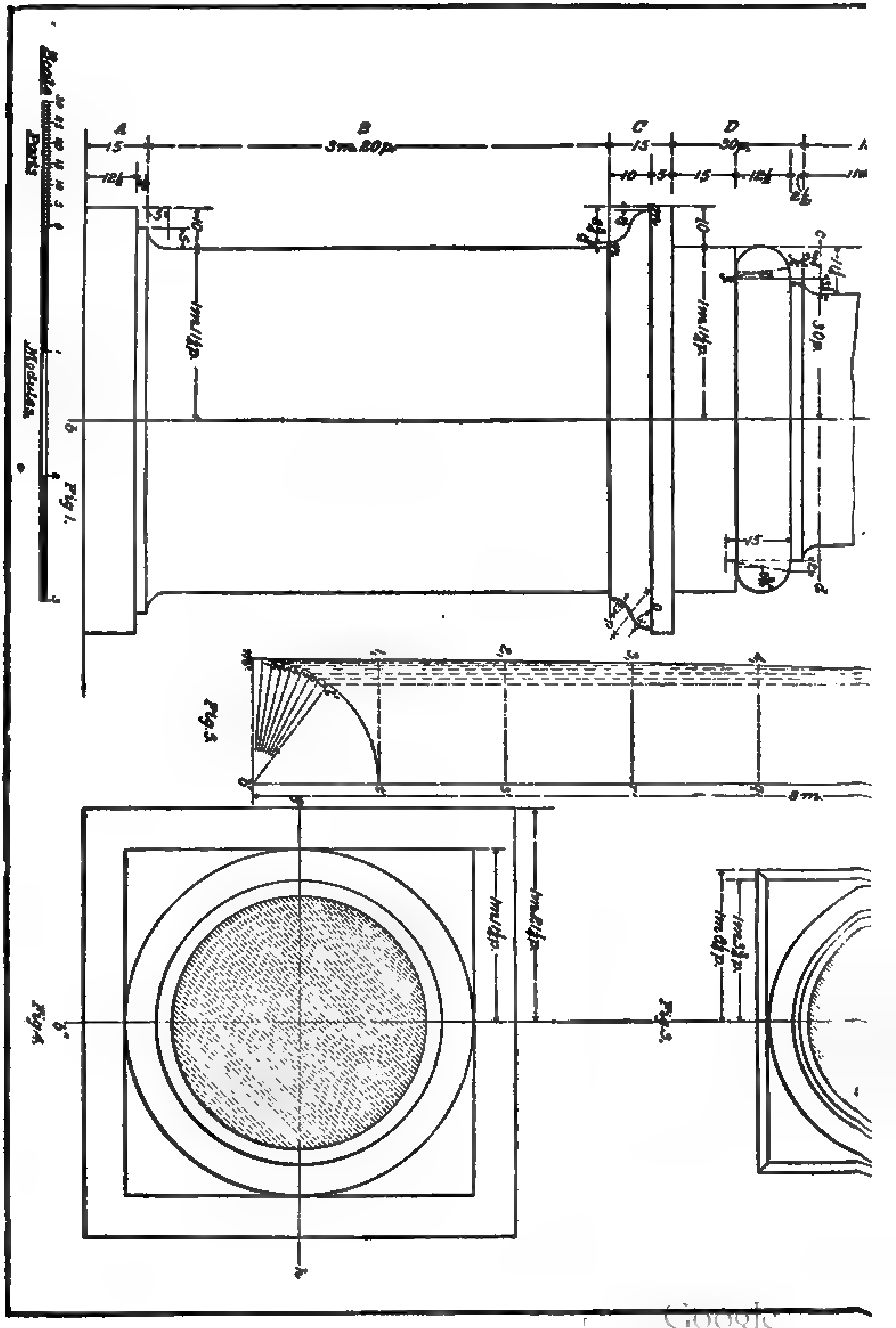


FIG. 7

Commence this plate by constructing a scale 4 in. in length, at a distance of $\frac{5}{16}$ inch above the lower border line, the module upon this plate being equal to 10 inches. Then draw *a b*, the center line of Fig. 1, at a distance of $4\frac{1}{8}$ inches from, and parallel to, the left-hand border line. Lay off on *a b* the horizontal divisions of the order, according to the dimensions given on the plate; profile the moldings of the capital and base of the column, and also at the returns of the entablature and pedestal, striking all the curves with the bow-pencil, and from centers located according to the measurements given on the plate.

Now draw Figs. 3 and 4, which are plans of the under side of the capital and of the upper side of the base, respectively, locating the center line $a''\,b''$ at a distance of $2\frac{1}{4}$ inches from, and parallel


Scale
Parts
Modules
Fig. 1
Fig. 3
Fig. 4
Fig. 5

TUSCAN ORDER.

Scale 1½" = 1 ft.

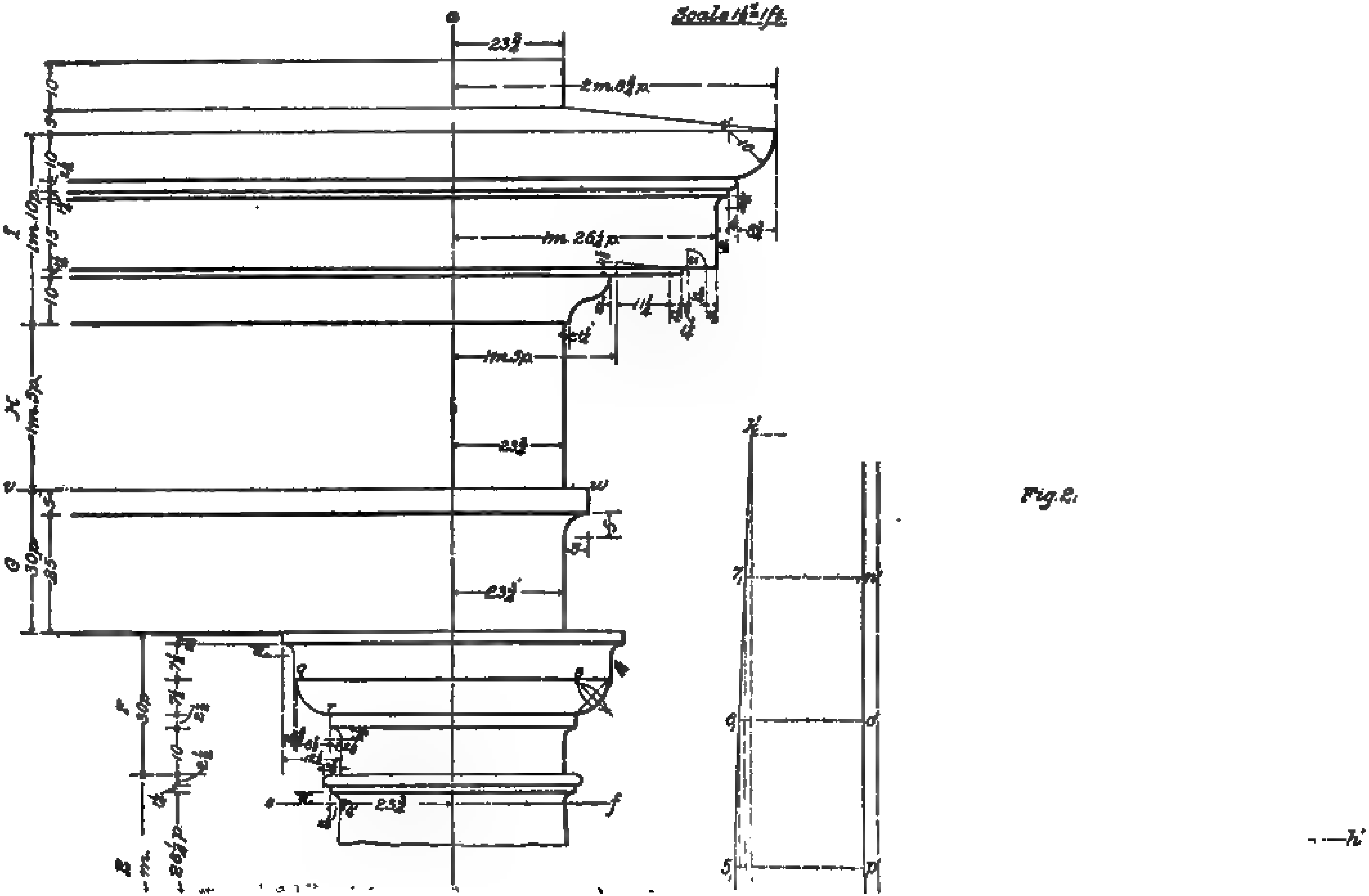


Fig. 2.

to, the right-hand border line; and the lines $g' h'$ and $g h$, $8\frac{1}{8}$ inches and $2\frac{1}{8}$ inches, respectively, above the lower border line. Draw the circular outlines of the moldings on the capital and base, in Figs. 3 and 4, from measurements taken from Fig. 1, and complete the figures. Then draw the soffit, or under side of the entablature, shown in Fig. 2. Locate the center line $a''' b'''$ $3\frac{5}{8}$ inches from, and parallel to, the right-hand border line, and draw $g'' h''$ $4\frac{1}{4}$ inches below the upper border line; then, from the dimensions given on Fig. 1, complete Fig. 2, as shown.

Fig. 5 is a half elevation of the upper part of the shaft of the column, showing the method of profiling the curved outline of the shaft, which is called the **entasis.** The architectural purpose of the entasis is to prevent the shaft of the column from appearing too slender, and to destroy the optical illusion of concave sides, which is likely to appear when the lines of a shaft are parallel. Draw the center line $a' b'$ $5\frac{1}{4}$ inches from the right-hand border line, and 8 m. in length; then divide it into 8 equal parts of 1 m. each. Through these points of division draw the horizontal lines $t' 1'$, $s' 2'$, $r' 3'$, etc. Now, on b' as a center, and with a radius of 1 m., draw the arc $m' t'$. Make $a' k'$ $23\frac{3}{4}$ p., or one-half the upper diameter of the column. From k' draw $k' l'$ parallel to $a' b'$ and intersecting the arc $m' t'$ at l'. Divide the arc from m' to l' into 8 equal parts, as shown at 1, 2, 3, etc., and from each of these points of division erect a perpendicular line, to intersect with the horizontal lines drawn through $n' 7_1$, $o' 6_1$, $p' 5_1$, etc.; then through the points k', 7_1, 6_1, 5_1, etc. draw the curve of the entasis.

Now finish the plate, putting in all dimensions and dimension lines, but omitting all reference letters except those on Fig. 5.

DRAWING PLATE, TITLE: DORIC ORDER

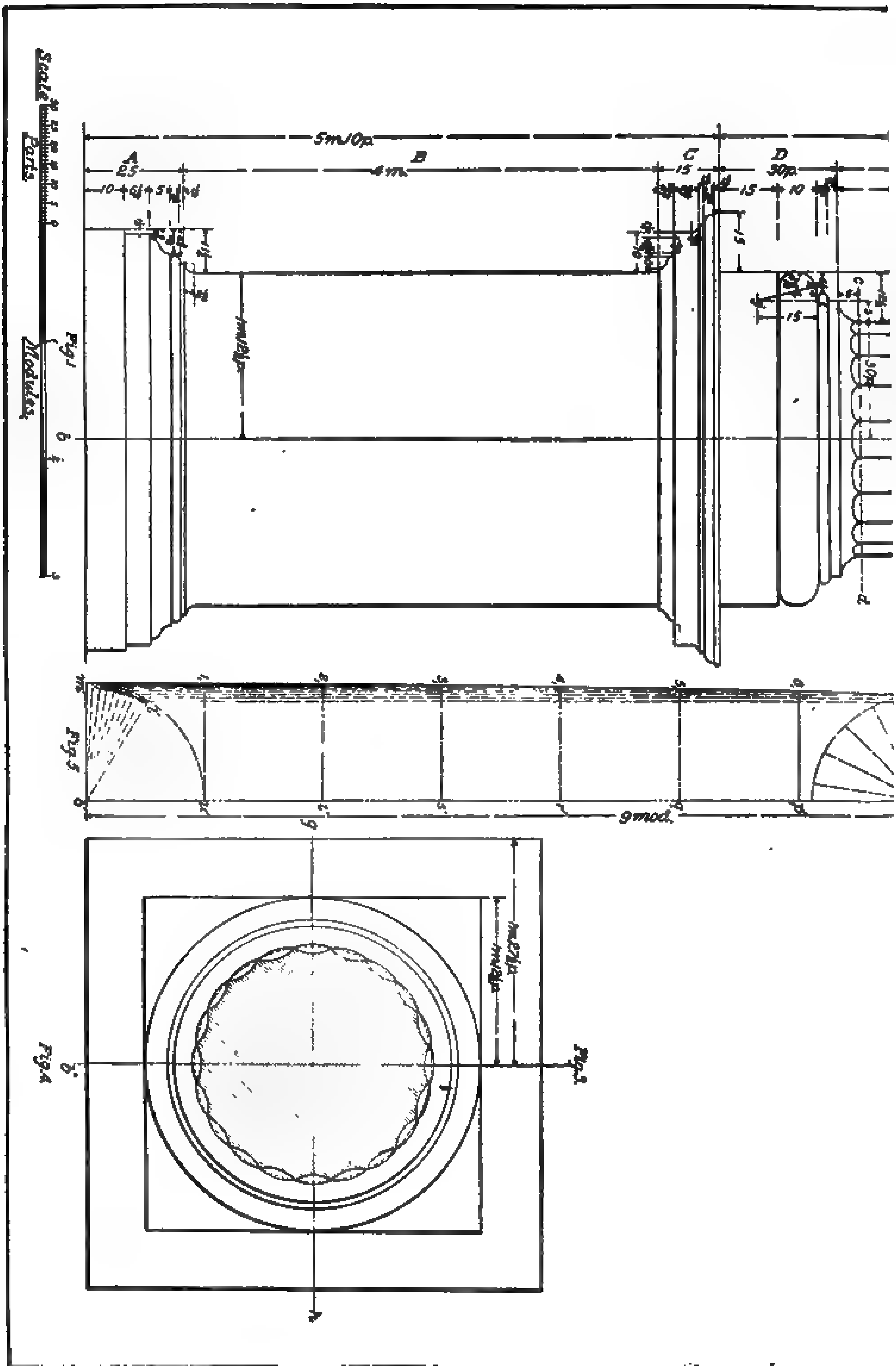
7. The Roman-Doric order, Fig. 8 of the text, though similar in many of its details to the Greek order of the same name, as shown in Fig. 1, is, as a whole, so modified that it

would hardly be recognized as a descendant of the Grecian design. The stylobate here is in the form of a pedestal, and the column stands upon a molded base, which never existed in the Greek Doric. The flutes of the shaft are somewhat similar to those of the Greek order, but are composed of circular instead of elliptical arcs. The capital is decidedly different, and though the frieze still possesses the triglyphs and metopes, these details are differently proportioned and less regularly spaced than in the Greek order. The mutules are level on their under sides, and the crowning member of the corona is a cyma recta instead of an echinus.

Commence this plate by constructing a scale of modules $\frac{5}{16}$ inch above the lower border line. The diameter of the column being 18 inches, the module will be 9 inches, and the scale should be made 4 m. in length, with the first module divided into 30 p. as shown.

Draw $a\,b$, the center line of Fig. 1, at a distance of $4\frac{1}{2}$ inches from, and parallel to, the left-hand border line. Measure off on $a\,b$ the horizontal divisions of the order, and draw the lines defining these divisions. Profile the moldings of the pedestal, column, and entablature according to the measurements given,

FIG. 8


Scale
Parts
Modules.
Fig.1
5m.10p.
A
B
C
D
25
4m.
15
30p.
Fig.3
9 mod.
Fig.4
Fig.2

DORIC ORDER.

and draw the triglyphs and mutules in the entablature. Complete Fig. 1, omitting for the present the fluting of the shaft. Now draw Figs. 3 and 4, which are plans of the under side of the capital and upper side of the base, respectively. Draw the center line $a'' b''$ 2¼ inches from, and parallel to, the right-hand border line. Draw $g h$ 2¼ inches and $g' h'$ 7⅜ inches above the lower border line. Draw the circular plan of the moldings of the base and capital and the circular plan of the shaft. Draw the rectangular outlines of the moldings on the abacus in Fig. 3, and of the plinth and pedestal in Fig. 4. Divide the circumferences of the circles defining the plan of the column in Figs. 3 and 4 into 20 equal parts, and with the chord length of one of these parts as a radius, describe the arcs defining the flutes. Project the arrises between these flutes to the lines $g h$ and $g' h'$, and with a paper strip transfer their positions to Fig. 1.

Draw Fig. 2, which is a plan of the under side of the entablature, locating the center line $a''' b'''$ 4 inches from, and parallel to, the right-hand border line, and draw $g'' h''$ 4½ inches below the upper border line. Draw in the moldings and plans of the mutules from the dimensions given in Fig. 1, and carefully outline the panels *J*, *K*, *L*, *M*, and *N* between the mutules.

Draw Fig. 5 in the same manner as described for the previous plate, locating the center line $a' b'$ 5⅝ inches from the right border line, and making it 9 m. in length, instead of 8 m. as before, and dividing the arc $m' l'$ into 9 equal parts.

On a', n', o', etc. as centers, and with $a' k'$, $n' 8_1$, $o' 7_1$, etc. as radii, describe quadrants as shown, and divide each quadrant into 6 parts, the first and last division being 9° each, and the intermediate divisions 18° each. These points of division will locate the positions of the arrises between the flutes, on the lines $a' k'$, $n' 8_1$, etc. Project these points from the circumferences of the quadrants to the lines from which the quadrants start, as $a' k'$; $n' 8_1$, etc., and through them draw the lines of the flutes of the shaft as shown.

Fig. 5 shows only the upper two-thirds of the column, as the sides of the lower third are parallel. Now complete Fig. 1, drawing the flutes in the upper part of the column from measurements taken from Fig. 5, and in the lower part of the column from measurements taken from Fig. 4, as previously explained.

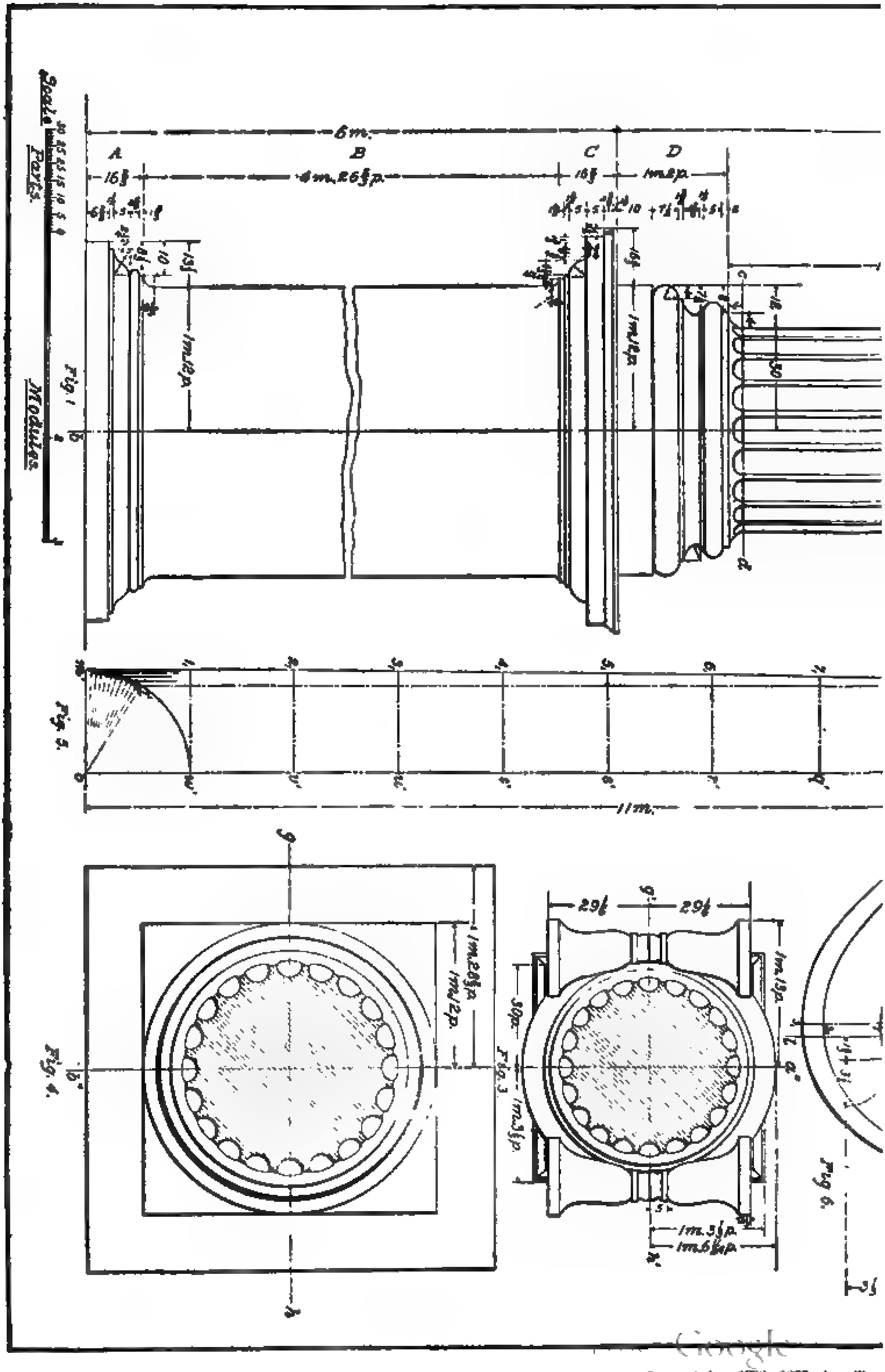
DRAWING PLATE, TITLE: IONIC ORDER

8. The Roman-Ionic order differs from the Grecian order, principally in the formation of the volutes of its capital, and the addition of the pedestal, as may be seen by comparing Fig. 9 of the text, which is a perspective of the Roman-Ionic order, with Fig. 4, the perspective view of the Greek Ionic.

The column in this plate is 16 inches in diameter, and the module is consequently 8 inches. Construct a scale 4 m. in length, $\frac{3}{4}$ inch above the lower border line; then commence Fig. 1 by drawing the center line $a\,b$ $4\frac{1}{2}$ inches from, and parallel to, the left-hand border line. Lay off on $a\,b$ the horizontal divisions of the order, and draw the lines defining these divisions. Complete Fig. 1 from the measurements given, except the flutes of the shaft and the volutes of the capital.

Now draw Fig. 6, which is an elevation of the volute of the capital, four times the size of this detail in Fig. 1, or according to a scale of 6 inches = 1 foot. Draw $k\,l$ 3 inches from, and parallel to, the right-hand border line, and $i'j'$ $9\frac{1}{4}$ inches above the lower border line. From the intersection of these lines lay off on $k\,b$ 15 p. towards k, and draw the horizontal line 1_1–1_2; divide the distance from 1_1 to the intersection of $k\,l$ and $i'j'$ into 8 equal parts, and, with one of these parts as a radius, and with a center at the point of intersection, describe a circle, which will be the eye of the volute.

The method of drawing the curves of this volute being essentially different from that practiced by the Greeks, it will be necessary for the student to leave Fig. 6 for the present, and give his attention to Fig. 7, which shows the


Scale
Parts
Modules
6m.
A
B
C
D
Fig. 1
Fig. 5.
11m.
Fig. 4.
Fig. 3
Fig. 6.

eye of the volute, drawn three times the scale of Fig. 6. Draw *a b*, Fig. 7, 6⅞ inches from, and parallel to, the right-hand border line, and draw *c d* at right angles to *a b* and 3⅞ inches below the upper border line. Now, with a radius of ¾ inch, and a center at the intersection of *a b* and *c d*, draw a circle whose diameter will be three times that of Fig. 6; then draw the lines *a c*, *a d*, *b c*, and *b d*; bisect *a c* and *a d* in points *2* and *1*, respectively, and draw radial lines from these points to the center of the circle; divide the line *2–12* into 3 equal parts, marking points at *6* and *10*. Through points *2*, *6*, and *10* draw lines parallel to *c d*; the vertical distance between the lines *2 1* and *c d* will then also be divided into 3 equal spaces. Now draw the line *3–4* at a distance from *c d* equal to 2½ of these spaces; from points *2* and *5* draw vertical lines defining the points *3* and *4*; from the latter points draw diagonal lines at an angle of 45°, intersecting on line *c d*; draw verticals from *6* to *7*, *10* to *11*, and *9* to *8*, and horizontals from *7* to *8* and *11* to *12*, thus completing the figure. The centers for drawing the arcs of the volute are at *1*, *2*, *3*, *4*, etc., and will be used in the order in which they occur.

FIG. 9

Locate the centers in the eye of Fig. 6, by the method followed

in Fig. 7, and proceed to draw the arcs. From center *1*, with a radius equal to 1–1_1, draw the arc 1_1–2_1; from center *2*, with a radius equal to 2–2_1, draw the arc 2_1–3_1, and continue thus until the outer line of the volute is complete. Before drawing the inner line of the fillet of the volute, which gradually diminishes to a point where it unites tangentially with the eye, it will be necessary to define its width at the end of each arc; draw the fillet line 1_2–1_1 at a distance of $1\frac{3}{4}$ parts below the upper line 1_1–1_1, and on it mark any point, as at *m*; divide the length of the line $m\,1_1$ into 12 equal spaces, as 1_1–2_1, 2_1–3_1, etc.; join *m* and 1_2 by an oblique line, as shown; from the points 1_1, 2_1, 3_1, etc. draw vertical lines intersecting the oblique line at 1_2, 2_2, 3_2, etc.; the length of the line 1_1–1_2 being equal to 1_1–1_2 at the springing of the volute, it need not be transferred, but with the dividers set to the distance 2_1–2_2, transfer it to 2_1–2_2 on the line 2_1–1 at the end of the first arc, as shown; transfer these ordinates from the oblique line to the radial lines on the spiral, as shown, and in consecutive order.

Now, from the point 2_2, on the horizontal line of the spiral 2_1–1, mark a distance equal to the vertical line 1_2–1; from the point marked, describe the arc 1_2–2_2; then, from the point 3_2 on the vertical line 3_1–2, mark a distance equal to the horizontal line 2_2–2, and from the point marked describe the curve 2_2–3_2, continuing thus until the fillet of the spiral unites at the last convolution with the eye. Mark the widths of the moldings adjacent to the volute, and profile them as shown; the reverse curve *k n o* shows the curvature of the bolster on the center line *g′ h′* of Fig. 3.

Now draw the volutes and finish the capital in Fig. 1, and then proceed with Fig. 3. Draw *a b* $2\frac{1}{8}$ inches from, and parallel to, the right-hand border line; draw *g′ h′* $6\frac{1}{8}$ inches above the lower border line. Draw the upper circumference of the column; divide this circumference into 20 equal parts, and draw the fillets and flutes of the column, each fillet being one-third the width of a flute; draw the moldings of the neck and of the abacus, as well as the bolsters between the volutes, freehand. Now draw Fig. 4, the plan of the base

and pedestal. Draw the center line $g\,h$ $2\frac{11}{16}$ inches above the lower border line, and with the point of its intersection with $a''\,b''$ as a center, and a radius of 1 m., draw the circular plan of the column; divide the circumference of this plan into 20 equal parts, and draw the flutes and fillets; then draw the moldings of the base and the plan of the plinth and pedestal.

Now profile the entasis of the column as shown in Fig. 5. Draw the center line $a'\,b'$ at a distance of $7\frac{7}{16}$ inches from the left-hand border line, and draw the base line $m'\,b'$ in line with that of the pedestal in Fig. 4. Draw the upper line $k'\,a'$ 11 m. above $m'\,b'$; make $k'\,a'$ equal to the semi-diameter of the shaft at the neck, which is 25 p. From b' as a center, with a radius of 1 m., describe the arc $m'\,w'$. From k' draw a line parallel to $a'\,b'$, intersecting the arc at l'; divide the arc $m'\,l'$ into 11 equal portions, as shown at *1*, *2*, *3*, etc.; divide the center line $a'\,b'$ into 11 equal portions, and draw horizontal lines $1_1\,w'$, $2_1\,v'$, etc.; from the point *1* on the arc, draw a line parallel to $a'\,b'$; its intersection with the line $1_1\,w'$ will give one of the required points. From *2* draw a similar line to 2_1, etc. All the points being marked, draw a curve through them by means of a spline, or flexible strip.

Draw the line of the shaft below the neck of the capital on Fig. 1, parallel to $k'\,10_1$ of Fig. 5, which will give the taper of the shaft at that section; draw the taper of the opposite line by a measurement from the center line $a\,b$. Since the lower portion of the shaft is cylindrical, the lines representing this portion will be parallel to the center line $a\,b$. In order to draw the fluting of the lower portion of the shaft on Fig. 1, project the edges of the flutes on Fig. 4 down to the center line $g\,h$, by drawing a series of lines parallel to the center line $a''\,b''$; then transfer their position on line $g\,h$ by means of a strip of paper on which the points have been punctured, carefully noting the position of the center line $a''\,b''$.

To draw the fluting of the upper portion of the shaft, a different procedure will be necessary. From points a', n', and o' on Fig. 5, with radii equal to the semi-diameter of the shaft at the section on which these points are located, describe

quadrants; divide each arc into 5 equal spaces from the points marked on the arc, which will be the centers of the flutes; with a radius equal to two-fifths the length of the arc between the centers of the flutes, describe the semicircles defining the flutes; project the lines of the fillets between the flutes to their position on the horizontal lines $k'a'$, etc., by drawing lines parallel to the center line $a'b'$; through the three points established for the edge of each flute, draw a curved line by means of a spline. Transfer the position of the edges on the line $k'a'$ to ef of Fig. 1, and draw the edges of the flutes on Fig. 1 parallel to those on Fig. 5.

Now draw Fig. 2, the plan of the soffit of the entablature. Draw $a'''b'''$ $3\frac{5}{16}$ inches from the right-hand border line, and $g''h''$ $3\frac{11}{16}$ inches below the upper border line. The projection of the moldings may now be obtained from Fig. 1, and the lines drawn in Fig. 2. Complete the plate, putting in all dimensions, and cross-hatching all parts shown in section.

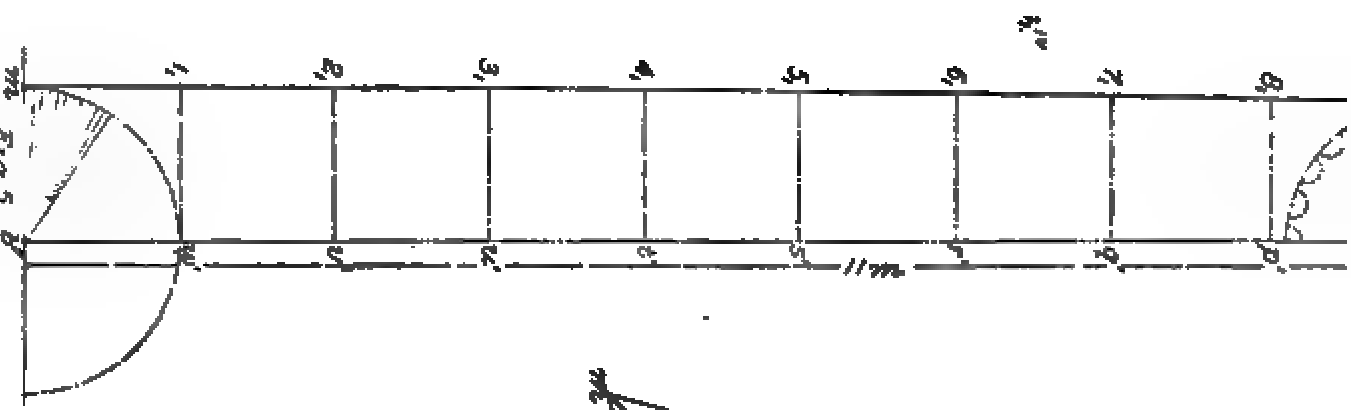
DRAWING PLATE, TITLE: CORINTHIAN ORDER

9. The Roman-Corinthian order, Fig. 10 of the text, differs from its Greek prototype principally in the elaboration of its entablature and the arrangement of the foliage of its capital.

The diameter of the column in this plate being 14 inches, the module is 7 inches in length. From a point $1\frac{1}{4}$ inches from the left-hand border line, and $\frac{3}{8}$ inch above the lower border line, construct a scale 5 m. in length, as shown. Then commence Fig. 1 by drawing the center line ab $4\frac{1}{8}$ inches from, and parallel to, the left-hand border; and from a point $\frac{3}{4}$ inch above the lower border lay off on ab the measurements locating the horizontal divisions of the order, and draw lines defining these divisions. Profile the moldings of the pedestal, base, and entablature, according to the measurements on the plate, but omit the capital until the details of its foliage have been drawn.

Now draw Figs. 2 and 3, the plan of the under side and the angular elevation of the capital. Draw the center line $a''b''$

Scale



CORINTHIAN ORDER.

2⅝ inches from, and parallel to, the right-hand border line, and draw $g'' h''$ 6⅝ inches above the lower border line; with the point of intersection of $a'' b''$ and $g'' h''$ as a center, and with a radius of 25 p., draw a circle defining the outline of the bell as it would be on the section line $i j$ of Fig. 1. From the same center, but with a radius of 1 m. 5 p., describe a circle defining the projection of the bell at the top; and, with a radius of 2 m., draw a circle limiting the projection of the angles of the abacus. Draw $k'' l''$, and with this line as a base, construct the equilateral triangle $k'' m l''$; mark the width of the angles of the abacus, 3½ p. each side of the axial lines as shown; and with m as a center describe the arc defining the concave side of the abacus. Draw the other three sides in the same manner, and sketch in, freehand, the circular blocks, from which the ornaments would be cut on each side of the abacus. Divide the circumference of the column section into 8 equal parts, as shown, and locate a stem of the foliage in the center of each of these parts.

Now draw Fig. 3, locating $u v$, the upper line of the abacus, 11¼ inches above the lower border line. Draw the horizontal lines of the abacus, bell, and astragal, according to the measurements given, and locate the center of the eye of the small volute 7½ p. below the abacus, and 20 p.

FIG. 10

from the neck of the column; then draw the volute freehand. Points in the curves of the volute may now be projected to Fig. 2, and the volute may then be drawn in place.

Complete Fig. 2, drawing the plan of the cauliculi, cauls, and volutes, and the molding lines on the angles and concave sides. The right side of Fig. 3 is left plain, to show clearly the outline of the bell, but on the left side the foliage is shown in position, the center lines of the stems being projected from Fig. 2. The dotted outlines on the extreme left show the projection of the two tiers of leaves, which is limited by a line drawn from the eye of the volute to the edge of the astragal.

A half plan of the capital should now be drawn, as in Fig. 6, making the line $g''' h'''$ a continuation of $g'' h''$. Draw the leaves in Fig. 6 as shown, obtaining their projection beyond the column line from the dotted outline in Fig. 3.

Now finish the capital in Fig. 1, projecting the lines of the abacus from Fig. 3, and profiling the moldings at the angles of the abacus, by projecting lines from Fig. 6. Draw in the leaves and cauliculi as shown, carefully drawing the curl at the tips of the leaves, according to the measurements given.

Now draw Fig. 4, the plan of the base and pedestal, locating $g' h'$ $2\frac{3}{8}$ inches above the lower border line. Draw the flutes of the column and moldings of the base, as described for the previous plate, and project the lines of the flutes to a strip of paper and transfer them to Fig. 1. Then draw the flutes in the lower part of the column in Fig. 1, and proceed to Fig. 5. The line $a' b'$ is located $5\frac{1}{8}$ inches from the right-hand border line, and is 11 in. in length. The arc $m w'$ is divided as shown, and the entasis of the column and flutes is described according to the method explained on the previous plate. Draw the flutes on the upper part of the column in Fig. 1, by marking them on a strip of paper and transferring them from Fig. 5; outline their finish, on the apophyge of the shaft, freehand.

Now draw Figs. 7 and 8, which are elevations of the side

and front of one of the **modillions,** or brackets, under the corona of the cornice, drawn to three times the scale of Fig. 1.

These modillions are a very much modified form of the Doric mutule, but are more elaborate than their prototype, combining in one design the scroll or volute of the Ionic capital and the rich foliation of the Corinthian. The extreme projection of the modillion is 29⅛ p., and its depth is 12¼ p. To proportion its details and locate centers for curves of the volutes, make *a b*, Fig. 11 of the text, equal to 30 p., the extreme projection of the corona, and divide it into 10 equal parts; then make *a c* equal to 9 of these parts. Make *d e*, the depth of the large volute, equal to ⅓ of *a c*, and draw *f h* through *e* and parallel to *a b*. Make *f g* equal to ⅙ *d e*, and divide *d e* into 14 equal parts. Then make *g h* equal to 36 of these parts, and draw *h n'*. The center *o* of the eye of the large volute is at the intersection of a vertical line drawn from the seventh of these parts and a horizontal line drawn from the sixth subdivision of *d e*, while the diameter of the eye is equal to 6 parts, as from *3* to *9*. In the smaller volute, the center *o'* of the eye is at the intersection of a vertical and horizontal line drawn from *34''* and *5*, respectively, and the diameter of the eye is 4 parts, as from *3* to 7 on *d e*. To find the centers of the arcs of the volute, describe a circle on *o* as a center, and with a radius equal to 1 part of subdivision of *d e*, within which draw a diagonal square as shown. The points *1*, *2*, *3*, and *4*, at the middle of the sides of this square, are the centers from which the arcs 1_1–2_1, 2_1–3_1, 3_1–4_1, and 4_1–5_1 are drawn, while points *5* and *6*, located half way between *o 1* and *o 2*, are the centers from which the last two arcs of the spiral are drawn. The width of the fillet at *q* is one-third of the distance from 1_1 to *p*, and diminishes to the width at 6_1–6_2, where the inner volute becomes tangent to the eye. Lay off 1_2 *q* equal to 6_1–6_2, and divide *q* 1_1 into 5 equal parts; then make the width of the fillet at 2–2_2 equal to the width at 1_2–1, diminished by one of these parts, and the width of the fillet at 3–3_2 equal to the width at 1_2–1, diminished by two parts, and so on to the point 6_2, where the fillet becomes tangent.

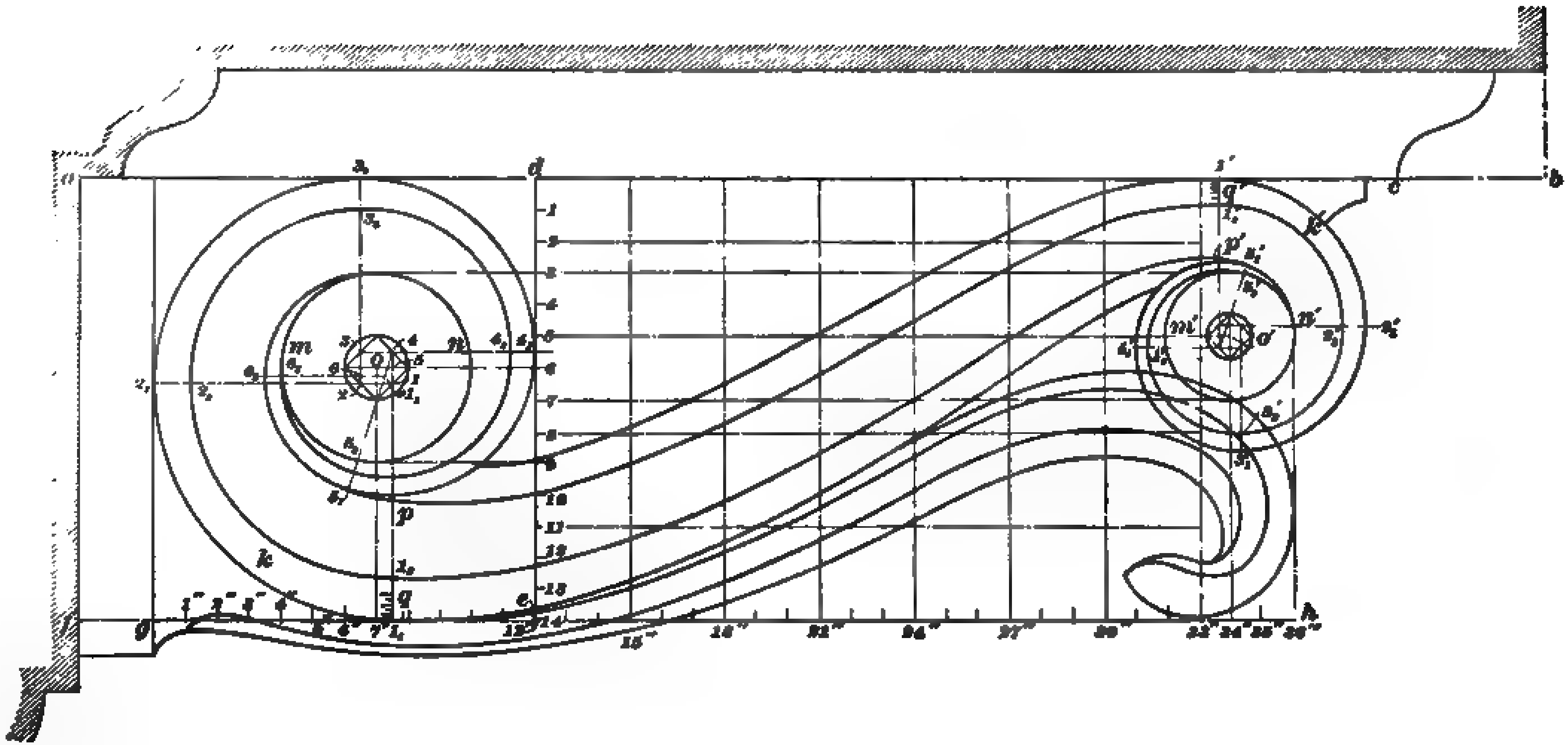


FIG. 11

The smaller volute is drawn in precisely the same manner, except that it is inverted; and, the eye being slightly larger in proportion to the extreme diameter of the volute, but five arcs are required for the spirals. The lines connecting the curves of the two volutes, and the outline of the curled leaf under the volutes, should be drawn freehand, with the aid of the system of squares, drawn as shown in Fig. 11 of the text.

Now draw the modillion on the plate, as shown in Fig. 7, locating the soffit line of the corona 4 inches below the upper border line, and the front of the corona $4\frac{3}{4}$ inches from the right-hand border line. Locate the center line of Fig. 8 at a distance of $3\frac{3}{4}$ inches from the right-hand border line, and draw the end elevation of the modillion from the measurements given, and with lines projected from Fig. 7.

Now draw the modillions in the cornice and complete Fig. 1; then draw Fig. 9 from the measurements given in Fig. 1, locating the axial lines $a''' b'''$ and $g''' h'''$ $3\frac{1}{4}$ inches and $3\frac{7}{8}$ inches from the right and upper border lines, respectively. Draw the entasis of the column and flutes as shown in Fig. 5, according to explanation for previous plates, locating the line $a' b'$ $5\frac{1}{4}$ inches from the right-hand border line.

DRAWING PLATE, TITLE: COMPOSITE ORDER

10. The Composite order was invented by the Romans in the endeavor to secure something more elaborate than the Corinthian. It is practically a combination of the Ionic and Corinthian, with proportions nearly identical with the latter, as shown in Fig. 12 of the text.

The diameter of the column in this plate is 14 inches, the same as in the previous order, and the module is consequently the same, i. e., 7 inches in length.

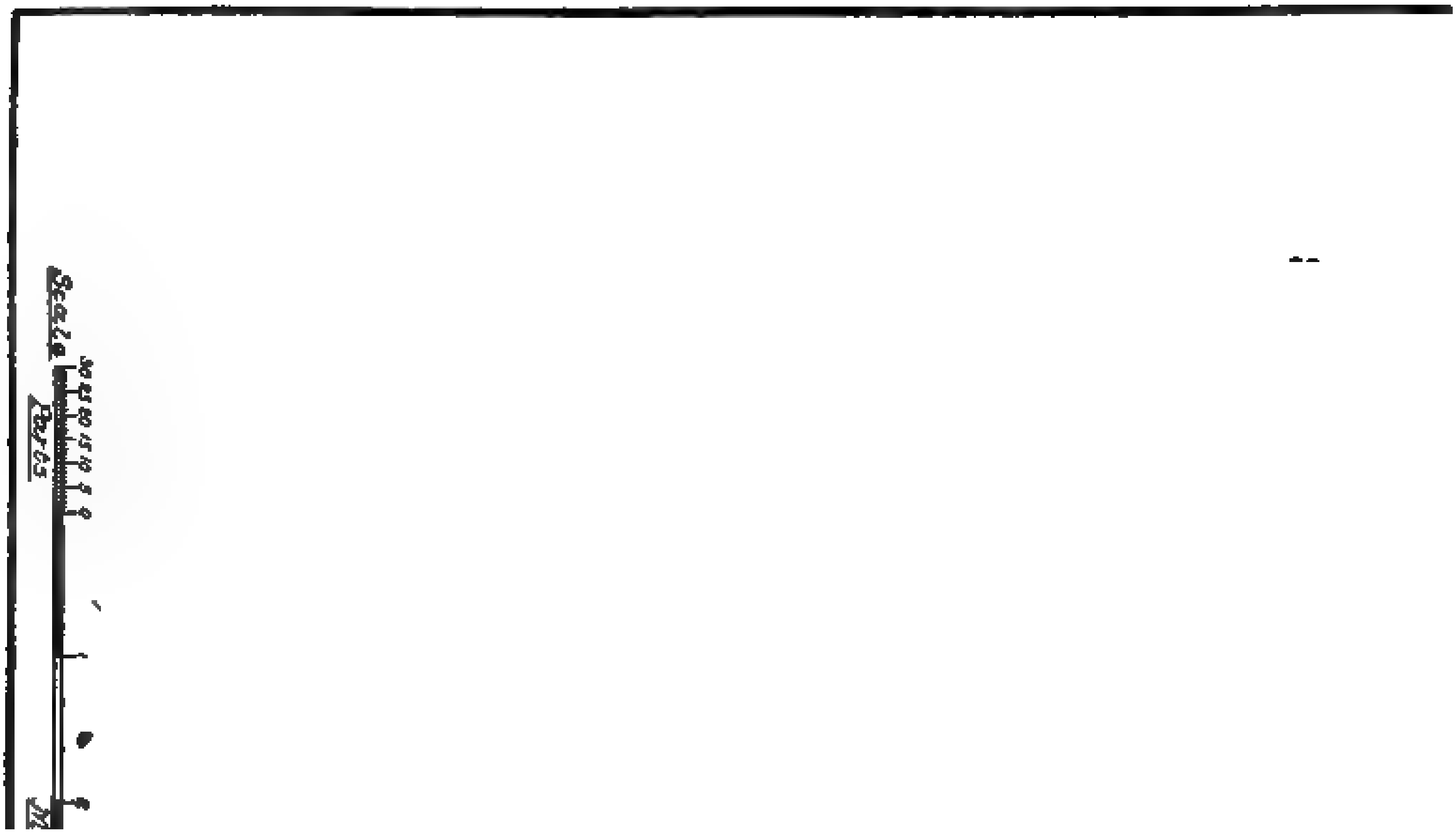
Construct a scale of modules $\frac{1}{4}$ inch above the lower border line, and $2\frac{1}{8}$ inches from the left-hand border line. Draw $a b$, the center line of Fig. 1, 4 inches from the left-hand border line; and from a point $\frac{3}{4}$ inch above the lower border, lay off on $a b$ a series of measurements, locating the horizontal

divisions of the order, and draw the lines defining these divisions. Profile the moldings of the pedestal, base, and entablature, according to the measurements given. Draw the dentils in the cornice, and complete the figure, except the capital of the column and the fluting of the shaft.

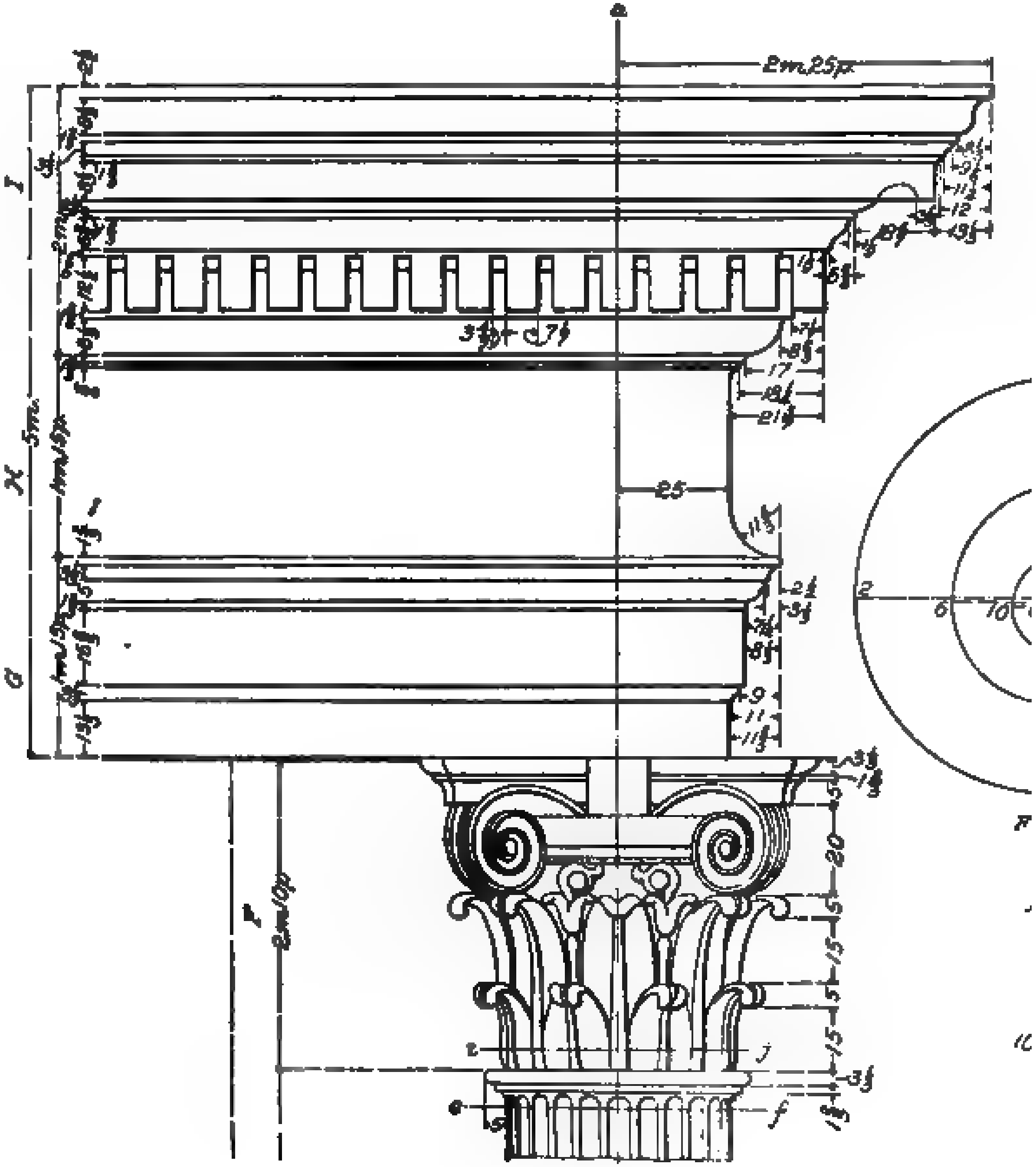
Now draw Figs. 2 and 3, the plan of the under side and the angular elevation of the capital. Draw the center line $a'' b''$ $2\frac{3}{8}$ inches from the right-hand border line, and draw $g'' h''$ $6\frac{3}{8}$ inches above the lower border line. With the point of intersection of $a'' b''$ and $g'' h''$ as a center, and with a radius of 25 p., draw the circular outline of the bell; and, with a radius of 1 m. 3 p., draw the outline of the echinus at the top of the bell. Then draw the moldings under the echinus and the circle limiting the projection of the angles of the abacus. Draw the concave sides of the abacus according to the method described for the previous plate; locate the blocks in the center of the sides, and complete the figure, except the volutes, which must first be drawn in Fig. 3.

FIG. 12

Draw $u v$, the upper line of the abacus in Fig. 3, at a



COMPOSITE ORDER.



distance of 11¼ inches above the lower border line. Lay off the measurements locating the horizontal divisions, and draw the lines defining these divisions. Profile the moldings of the abacus, bell, and astragal, and locate the center of the eye of the volute according to the measurements given. With a radius of 1¾ p., describe a circle as the eye of the volute. The eye must then be divided as shown in Fig. 8, and the arcs of the spiral may be described as shown in Fig. 7, according to the method explained for the drawing of the volutes in the Ionic order. Now complete the volute on the left-hand side of Fig. 3, and project the principal points of its curves to the plan, Fig. 2. Draw the plan of the volutes in Fig. 2, and project the principal points of the curves in plan to intersect with lines drawn from similar points in Fig. 3, and through these points of intersection draw the elevation of the volutes on the center line of Fig. 3.

Now complete Figs. 2 and 3 entirely, and draw the capital in Fig. 1. The plan of the capital, Fig. 6, may be traced and transferred from Fig. 2, the leaves being drawn in, according to the projections figured for them in Fig. 3. Complete Fig. 6, and project the details to the capital in Fig. 1. Then draw the plan of the base, Fig. 4, locating *g′ h′* $2\frac{5}{16}$ inches above the lower border, and draw the entasis of the shaft and flutes as shown in Fig. 5, according to the description given for the previous plate, locating *a′ b′* 5⅝ inches from the right-hand border line. Now complete Fig. 1, drawing the flutes from Figs. 4 and 5. Then draw Fig. 9, locating *a′ b′* 3¼ inches from the right border line, and *g h* 3⅞ inches from the upper border line. Complete the plate with all dimensions and dimension lines.

DRAWING PLATE, TITLE: IONIC DETAILS

11. This plate shows several details of the Roman-Ionic order, drawn to a scale of 1⅞ inches = 1 module. Draw the lower line of the scale at a distance of ⅝ inch above the lower border line; mark a point $5\frac{1}{16}$ inches from the left-hand

border line; from this point mark the lower diameter of the column, which is 3⅞ inches; divide this measurement into 2 equal parts, then subdivide the first division into 30 equal parts, as shown.

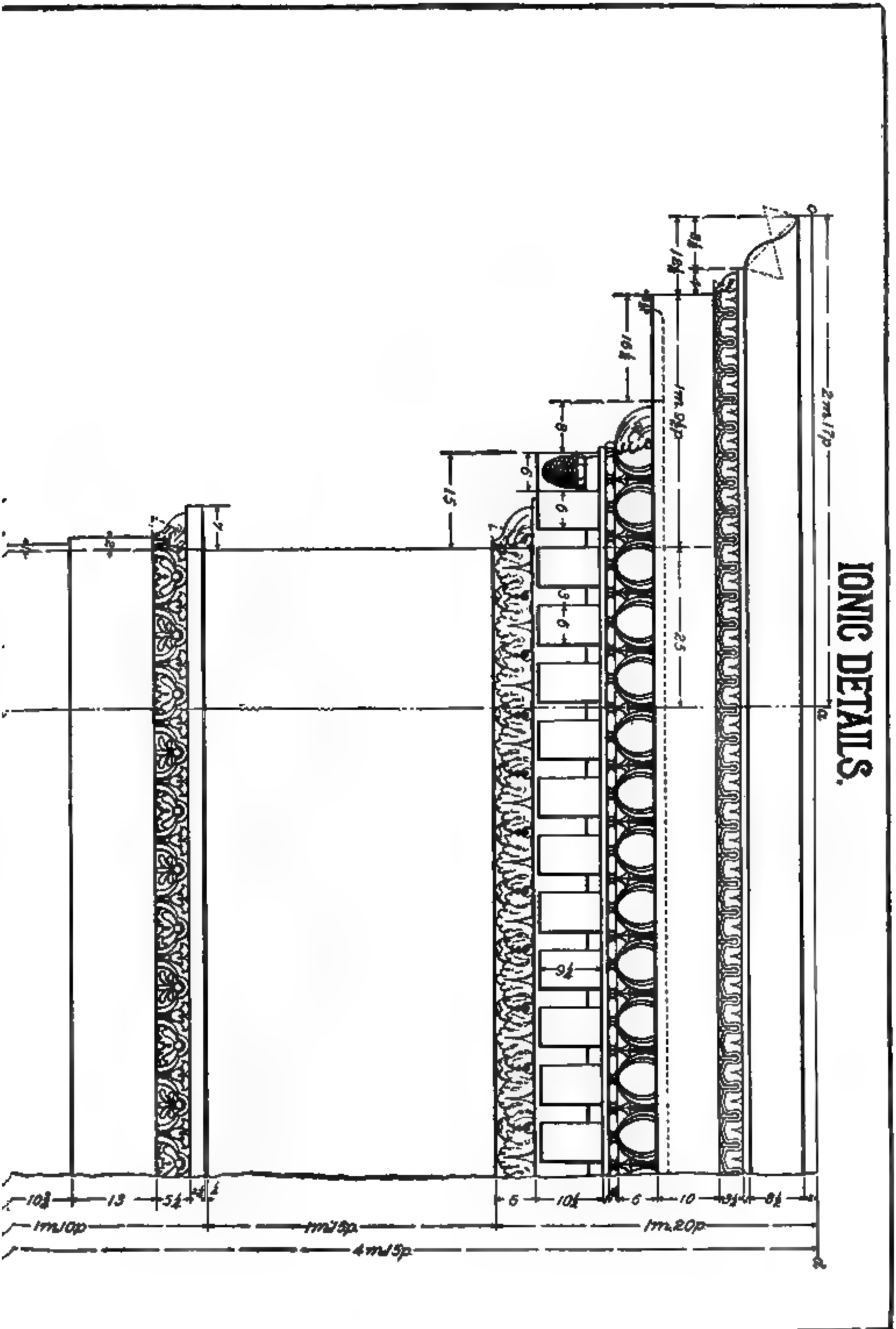
Proceed with Fig. 1, which is an *elevation of the column, capital, and entablature;* begin by drawing the center line *a b* at a distance of 6⅞ inches from, and parallel to, the left-hand border line; draw *c d*, the top line of the cornice, at a distance of 1/16 inch below the upper border line. From the line *c d*, mark a series of points on the center line *a b*, defining the principal divisions of the entablature thus: 1 m. 20 p. for the corniee; 1 m. 15 p. for the frieze; and 1 m. 10 p. for the architrave. Subdivide the architrave into three facias and a cymatium, the last named consisting of a cyma reversa and a fillet; subdivide the cornice into two equal divisions, the lower division being the bed mold, and the upper one the corona; subdivide the bed mold of the cornice into three divisions, measuring 6 p. for the cyma reversa, 10½ p. for the dentil course, and 8½ p. for the crowning members; subdivide the corona into three divisions, measuring 10 p. for the facia, 4½ p. for the cymatium, and 10½ p. for the cyma recta and fillet of the crowning member.

At a distance of 25 p. to the left of center line *a b*, draw the line of the return of the entablature; then profile the members of the architrave and cornice in accordance with the measurements given, drawing the curves with the bow-pencil.

Locate and draw the dentils in the dentil course in accordance with the measurements given. Draw the horizontal lines defining the members composing the capital; profile the *abacus*, which projects 8⅝ p. beyond the line of the shaft (which is also the line of the architrave); mark the centers of the eyes of the volutes, which are located at the intersections of the lower line of the echinus, with lines drawn at a distance of 30 p. from, and parallel to, *a b*, the center line of the column.

Within the eye, establish the centers and carefully draw each volute. The dotted lines on the face of the left-hand

IONIC DETAILS.



volute indicate the profile of the neck of the shaft of the column and the members of the capital.

Before drawing the flutes of the shaft, it will be necessary to draw Fig 5, the *plan of the shaft* at the commencement of the apophyge; draw the line *op* at a distance of 2$\frac{11}{16}$ inches above the lower border line; then, from the point of intersection of the line just drawn with the center line *ab*, with a radius of 25 p., describe a circle. As the surface of the shaft is channeled into 24 flutes, each quadrant of the circle defining its plan will have 6 flutes, and, as the angle at the center of each quadrant is 90°, the angle contained between the radial lines that pass through the center of each flute will be one-sixth of this, or 15°.

Divide the quadrant into 6 equal parts; then, from the points where the radial lines intersect with the arc, with a radius equal to two-fifths of the length of the arc between the radial lines, describe the flutes.

After the flutes have been drawn, the lines of the fillets between them can be projected up to Fig. 1. The curved stops of the flutes may be drawn freehand.

Draw Fig. 6, which is an *elevation of the plinth, base, and lower end of the shaft.* Commence by drawing the center line *qr* at a distance of 3$\frac{3}{8}$ inches from, and parallel to, the left-hand border line; draw *st*, the bed line of the plinth, at a distance of $\frac{3}{4}$ inch above the lower border line. On the line *qr*, commencing at the point *t*, lay off a series of measurements for its subdivisions; thus, 10 p. for the plinth, 7$\frac{1}{2}$ p. for the lower torus, 1$\frac{3}{8}$ p. for the fillet under the scotia, 4$\frac{7}{8}$ p. for the scotia, 1$\frac{1}{4}$ p. for the fillet over the scotia, 5 p. for the upper torus, 2 p. for the upper fillet, and 4 p. for the apophyge. At a distance of 30 p. to the left of the center line *qr*, draw the outer line of the shaft, and at a farther distance of 12 p. draw the return line of the plinth; locate and draw the fillet lines, and with the bow-pencil draw the upper and lower torus moldings with their respective radii.

In order to draw the scotia, which is a compound curve, first draw a line joining the corners of the fillets; on this

line as a base describe a semicircle; then, from the corner of the lower fillet, draw a line at an inclination of 30° from the horizontal; the line will intersect with the semicircle at the point shown; on this line erect an equilateral triangle; from its apex, with a radius equal to one of its sides, describe the lower portion of the curve; then, with a center at the point where the line of the upper fillet extended intersects the upper side of the triangle, describe the upper portion of the curve.

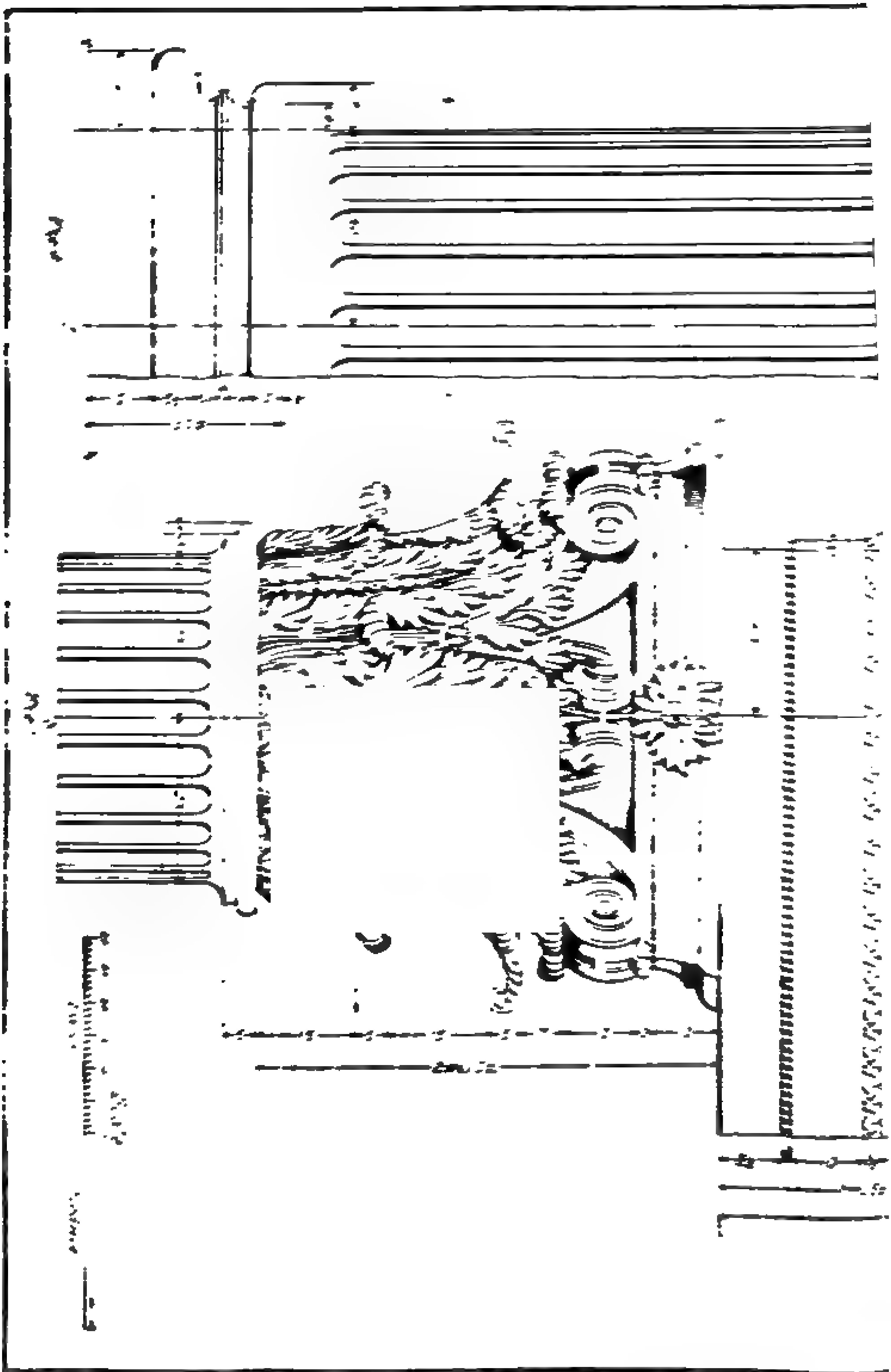
Draw Fig. 7, a *quarter plan of the shaft*, locating the axial line *u v* at a distance of 11⅝ inches above the lower border line; from *v* as a center, with a radius of 30 p., describe a quadrant; then subdivide the arc and draw the flutes by the method given for Fig. 5, and project the fillet lines down to Fig. 6.

Locate the center lines of the ornaments with which the molded members of the cornice are enriched, by means of scale measurements from the plate. Carefully draw in a section of each ornament, then trace and transfer to the adjacent sections. Draw the egg-and-dart enrichment cut in the echinus of the capital.

DRAWING PLATE, TITLE: CORINTHIAN DETAILS

12. This plate shows a study of several details of the Roman-Corinthian order, drawn to a scale of 1⅞ inches = 1 module. Draw this scale, at a distance of ¾ inch above the lower border line; mark a point 4¼ inches from the right-hand border line; from this point mark the lower diameter of the column, which is 3¾ inches; divide this measurement into 2 equal parts, then subdivide the first division into 30 parts.

Proceed with Fig. 1, which is an *elevation of the shaft, capital, and entablature*. Draw the center line *a b* 6⅜ inches from, and parallel to, the left-hand border line; draw *c d*, the top line of the cornice, ⅞ inch below the upper border line. From the line *c d*, mark a series of points on the



CORINTHIAN DETAILS.

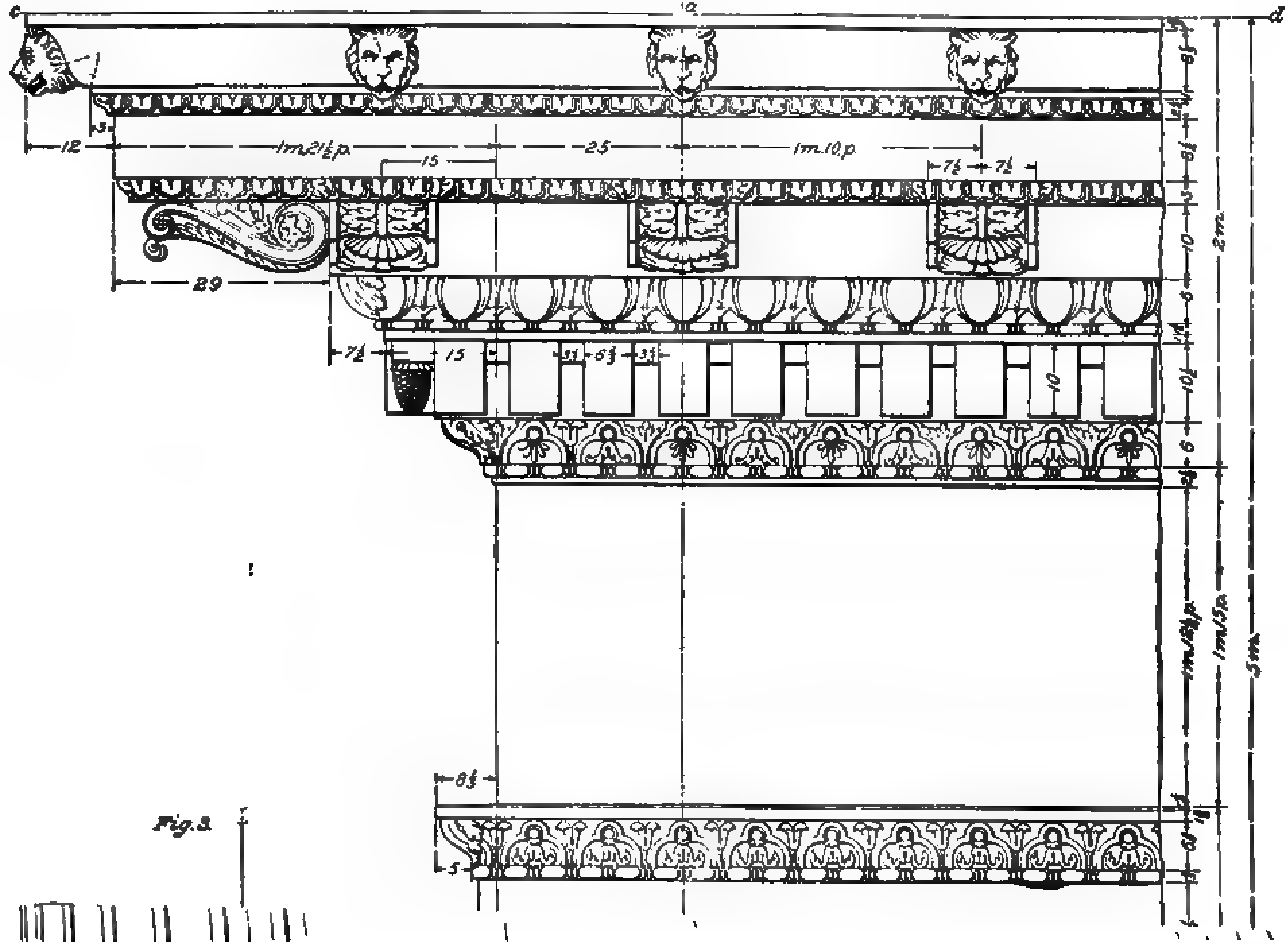


Fig. 3.

center line *a b*, defining the principal divisions of the entablature, giving 2 m. for the cornice; 1 m. 15 p. for the frieze, of which 2½ p. belong to the cymatium of the frieze; and 1 m. 15 p. for the architrave. Subdivide the architrave into facias and molded bands, and subdivide the cornice into its respective parts by horizontal lines, as shown.

At a distance of 25 p. to the left of the center line *a b*, draw the line of the return of the entablature, and profile the members of the architrave, frieze, and cornice, in accordance with the measurements given, drawing the curves with the bow-pencil. Locate and draw the dentils in the dentil course, as shown. Lay off the height of the capital, which is 2 m. and 10 p., and under the capital draw the astragal and fillet, defining the collar of the shaft.

Draw Fig. 2, which is a *half elevation of the base of the column and lower end of the shaft;* draw the center line *e f* at a distance of 3 inches from the left-hand border line, and draw *g h*, the bed line of the plinth, at a distance of ¾ inch above the lower border line. From the line *g h*, lay off a series of measurements defining the members of the base, as shown, and draw the horizontal lines. At a distance of 30 p. to the left of the center line *e f*, draw the outer line of the shaft, and profile the base, drawing the upper and lower torus moldings by means of the bow-pencil.

In order to draw the fluting at the lower end of the shaft, it will be necessary to draw Fig. 3, which is a *quarter plan of the shaft* on the line *i j*; draw *k l*, the axial line of the shaft, at a distance of 11½ inches above the lower border line, and from *l* as a center, with a radius of 30 p., describe a quadrant. Locate the centers for the flutes in accordance with the instructions given for previous plates, and project the fillet lines down to Fig. 2. The position of the flutes at the neck of the shaft of Fig. 1 can be determined by drawing from the center *l* of Fig. 3 a quadrant having a radius of 25 p., on which the fillet lines can be determined, thence projected to the line *k l*, and transferred to Fig. 1.

Commence the decorative features by locating the center lines of the modillions from the measurements given, and

draw the lines defining their width. Observe that the ornament on the various members of the cornice is regularly disposed, of which the center lines of the modillions may be taken as the regulators. Sketch one of them carefully, and then trace it and transfer to the other position. The lion heads, although now used in this position only as a decorative feature, were originally disposed as a series of waterspouts, the water from the roof being discharged through the open mouth.

Sketch in a section of the leaf ornament on the cymatium of the corona, between the center lines of the modillions, and also on the cymatium of the modillions and modillion band, and transfer to the adjacent sections. Observe that there is a leaf on the external angles of the modillions; a similar leaf is usually placed at the internal angles, so as to make a neater effect where the miter lines occur. Those on the internal angles are omitted, in order to prevent confusion on the elevation. Draw the egg-and-dart ornament on the echinus under the modillion band, and also the pearl-and-bead ornament under the echinus. Locate and draw the dentils in the dentil course, and sketch in the pendant in the angle, which is a conventionalized form of the pineapple.

Sketch in the side view of the modillion. The eye of the large volute is decorated with a leaf ornament, and the spandrel is occupied by a spray, growing out from the eye, and from which sprouts a group of petals; or the lower face of each modillion is decorated with an acanthus leaf similar to those on the capital.

Having drawn and completed the side view of the modillion, draw the molded outlines at the ends of the modillions, and sketch in the foliation on same. Draw the geometric element in the ornament over the frieze and on the cymatium of the architrave; this element is trefoil in form, and can be drawn by means of the bow-pencil; then fill in the spandrels and panels with the foliated and flower ornament. Sketch in the leaf ornament, and draw the beads on the enriched moldings between the facias of the architrave.

Draw the foliage of the capital of the column, first outlining the block form of the acanthus leaves, as was done on the drawing plate entitled, Corinthian Order; then subdivide into lobes and serrate the edges, as shown, and complete the plate.

DRAWING PLATE, TITLE: COMPOSITE DETAILS

13. This plate shows several details of the composite order, drawn to a scale of $1\frac{5}{8}$ inches = 1 module.

Draw this scale as shown, the lower line being $3\frac{3}{8}$ inches above the lower border line; mark a point $3\frac{1}{2}$ inches from the right-hand border line; from this point mark a distance equal to the lower diameter of the column, which is $3\frac{1}{4}$ inches; divide this measurement into 2 equal parts, and subdivide the first one into 30 equal parts, as shown.

Begin Fig. 1, an *elevation of the capital of the column and the entablature*, by drawing the center line *a b* at a distance of $7\frac{7}{16}$ inches from, and parallel to, the left-hand border line; draw *c d*, the top line of the cornice, at a distance of $\frac{13}{16}$ inch below the upper border line.

From the line *c d* mark a series of points on the center line *a b*, defining the principal divisions of the entablature, giving 2 m. for the cornice, 1 m. 15 p. for the frieze, and 1 m. 15 p. for the architrave. Subdivide the architrave into three parts, two of which are facias, and the third one a group of moldings crowning the architrave, the lower facia being $14\frac{1}{3}$ p., and the upper one $16\frac{2}{3}$ p., as shown. The facias are separated by a cyma reversa $3\frac{1}{3}$ p. wide, while the cymatium is composed of a bead of $1\frac{2}{3}$ p. and echinus 5 p., a cavetto $3\frac{1}{3}$ p. and a fillet $1\frac{2}{3}$ p. in width; subdivide the cornice into bedmold, dentil-course, facia, and crowning members, in accordance with the measurements given.

At a distance of 25 p. to the left of the center line *a b*, draw the line of the return of the architrave and frieze, and profile the molded members of the entablature, first locating the limits of their projections. Draw the curves by means of the bow-pencil.

Locate and draw the dentils in the dentil course, as shown. Draw the horizontal lines defining the members comprising the capital, the total height of which is 2 m. and 10 p.

Commence Fig. 2, a *half plan of the capital*, on line *e f*, looking upwards. Draw the line *g h* at a distance of $\frac{1}{4}$ inch above the lower border line; with a center on the point *b*, where the line *g h* intersects with the vertical center line *a b*, as a center, and with a radius of 2 m., describe a semicircle; then, from the center *b*, draw the diagonal lines *b i* and *b j*, each being at an angle of 45° from the line *g h*; through the points *i* and *j*, where the diagonal lines intersect with the semicircle, draw lines tangent to the semicircle; the width of the *nose*, or blunt end, being 8 p., lay off 4 p. on each side of diagonal lines, and mark the points *k*, *l*.

From the points *i* and *j*, with a radius equal to the horizontal distance between these points, strike two arcs which will intersect, above the plan, on the center line *a b*; and from the same points, with the same radius, describe arcs which will intersect on the line *g h* extended; from these points of intersection as centers, draw the curved lines, which should pass through the points *k* and *l*.

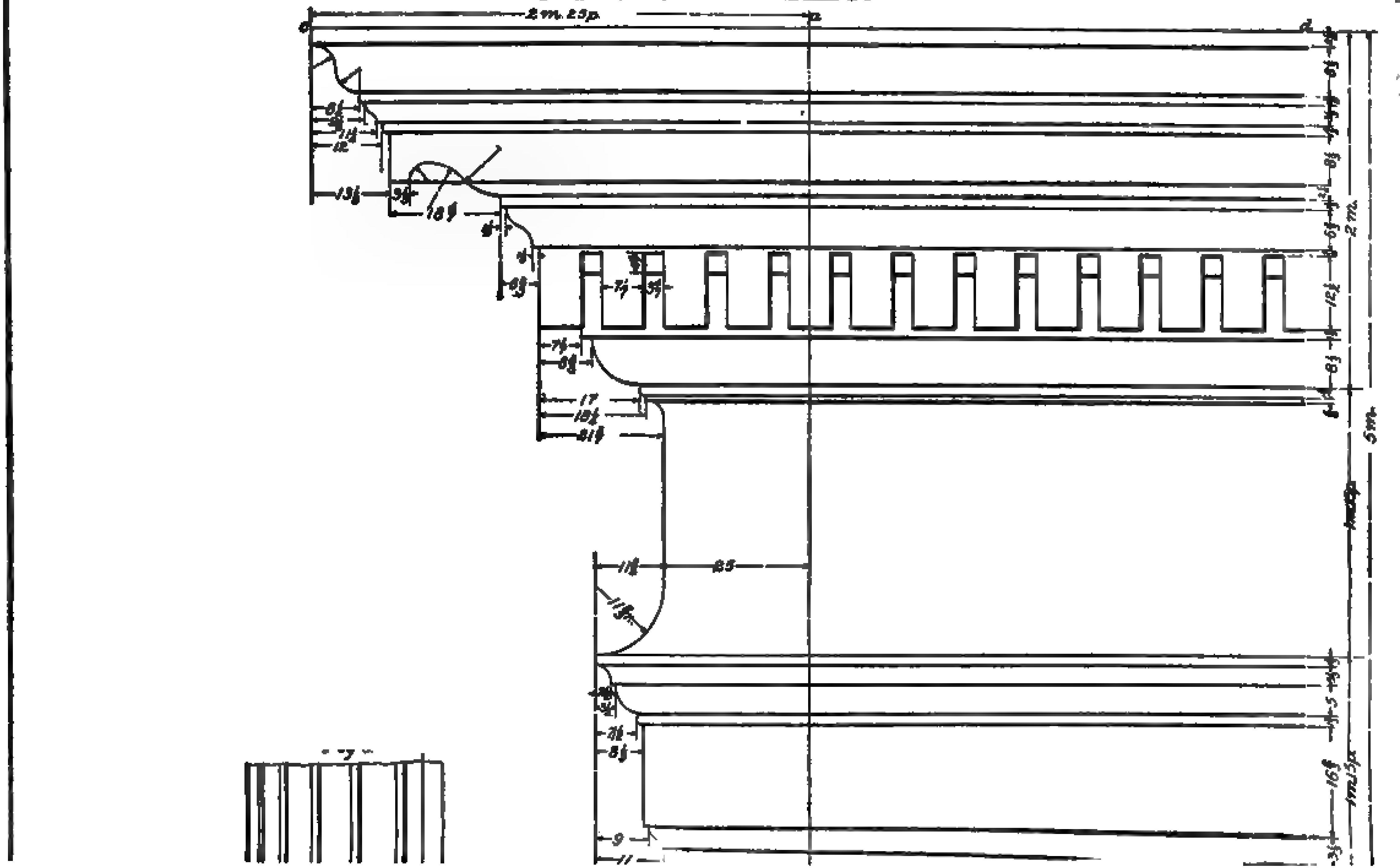
These curved lines define the concave sides of the abacus, the radius being about 2 m. and 21 p.

Lay off the widths of the molded members on the edges of the abacus in accordance with the measurements given, and draw the parallel curves as shown.

From the center *b*, with a radius of 25 p., describe a semicircle, which will represent the semi-diameter of the shaft of the column at the neck. Then, from the same center, with a radius of 1 m. and 9 p., describe a semicircle, which will give the projection of the large leaves; and with a radius of 1 m. and 4 p. describe a semicircle, which will give the projection of the small leaves.

Observe that the center lines of the large leaves are *a b*, *g h*, *b i*, and *b j*; in order to locate the center lines of the small leaves, bisect the angles contained between the center lines of the large leaves; sketch in one of the large and one

COMPOSITE DETAILS.



of the small leaves carefully, then make a tracing of the same and transfer to the other positions.

At a distance of 1 m. and 10 p. from the center b, mark points on the lines $b\,i$ and $b\,j$, and erect lines perpendicular to them, as at $m\,n$, which will locate the centers of the eyes of the volutes.

Sketch in one of the volutes, first locating the principal points by means of scale measurements taken from the plate; then trace and transfer to the opposite side. Project up the lines of the abacus and the principal points of the volutes to Fig. 1, observing that the center of the eye of the volute is in line with the lower line of the *echinus*, and is shown to be $6\frac{3}{4}$ p. in height.

Locate the principal points of the volutes, and sketch in one of them. In order to keep the drawing clean, and as practice and skill are necessary to draw the volute satisfactorily, the student is advised to practice on a separate sheet, first transferring the dimensions from the drawing to the sheet, and then to make a tracing and transfer the volute to the drawing plate.

Draw the horizontal lines that limit the heights of the leaves; project up the main points from Fig. 2, and sketch in the leaves on one side of the capital, which may then be traced and transferred to the other side.

The leaves shown represent the block form only. In practice the leaves would be subdivided into lobes and the edges would be serrated as in the previous plate; but in this example the block form is adopted for the sake of clearness and simplicity.

Proceed with Fig. 4, a *half elevation of the pedestal and base of the column.* Draw the center line $o\,p$ at a distance of $3\frac{13}{16}$ inches from the left-hand border line, and mark a series of points above $g\,h$ defining the members that compose the pedestal and base of the column. As the whole height of the pedestal is not shown, it will be necessary to draw $q\,r$, the top line of the cornice, at a distance of $5\frac{13}{16}$ inches above the lower border line, and mark the distances of the upper members from the line $q\,r$ just drawn.

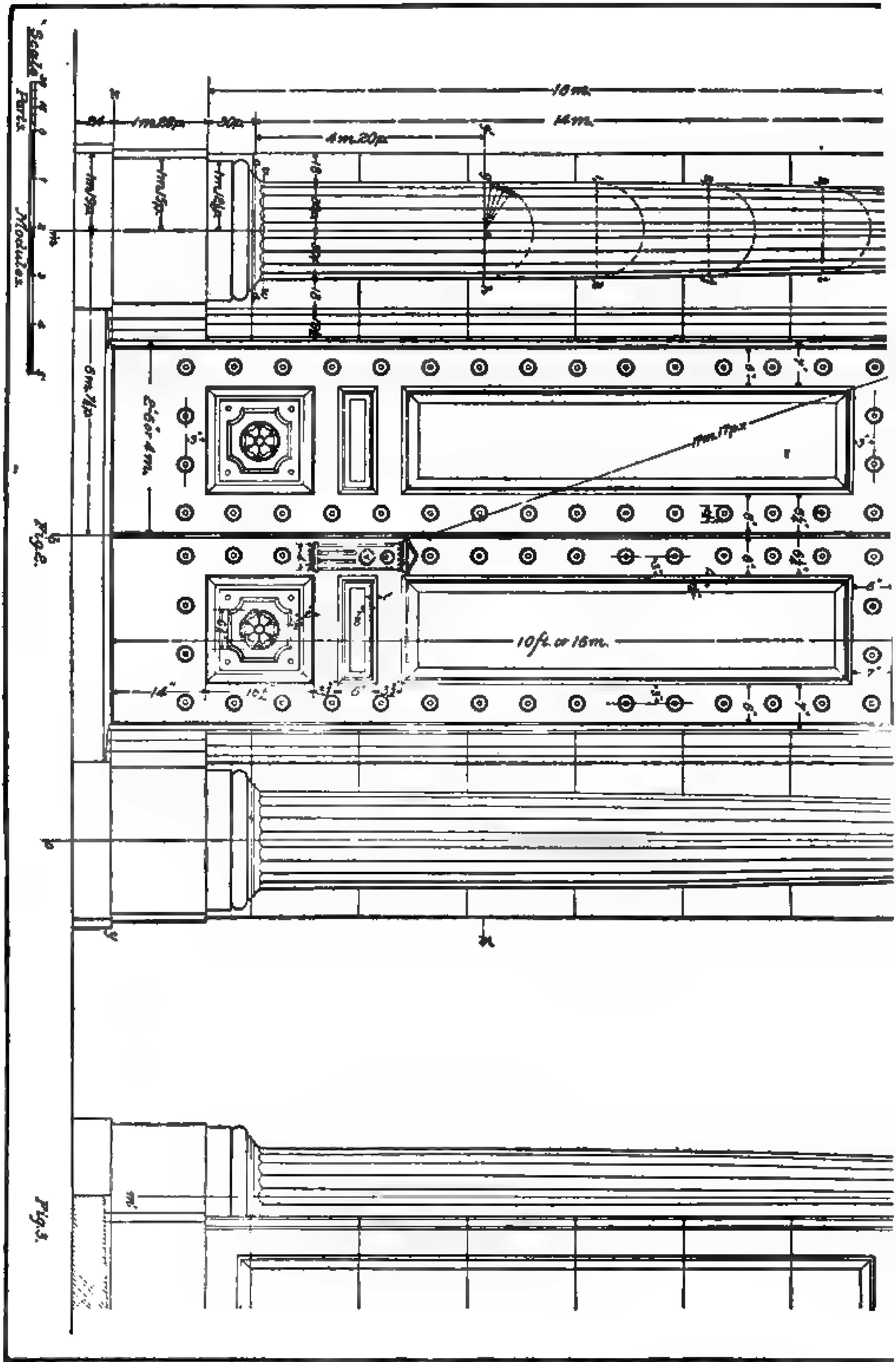
Having drawn the horizontal lines, draw the return line of the pedestal and the plinth under the base of the column, which is 1 m. 11⅝ p. from the center line *op*; then profile the molded members, using the bow-pencil where practicable.

Before drawing the flutes it will be necessary to draw Fig. 3, a *quarter plan of the column* on line *st*; from the center *v*, with a radius of 30 p., describe a quadrant and divide it into 6 equal parts; then from the center *v* draw radial lines through the points marked, and from these points as centers, with a radius of 3¼ p., describe the curves that define the flutes (the width of the fillets between the flutes will be one-fourth the width of the flute); now project the fillet lines down to Fig. 4, and complete the figure.

In order to draw the fluting of the column at the neck, as shown in Fig 1, make another quarter plan of the column with the diameter as it exists at the neck; thus, from the center *v*, on Fig. 3, with a radius of 25 p., which is equal to the semi-diameter of the column at the neck, draw a quadrant; the intersection of the radial lines previously drawn with the small quadrant will give the centers for the flutes. From the center *v* draw lines passing through the fillet lines of the large quadrant; their intersection with the small quadrant will give the reduced width of both fillets and flutes; project the fillet lines of the small quadrant up to the line *uv*, and transfer the points by means of a strip of paper to Fig. 1, observing carefully that the center line *op* of Fig. 3 coincides with the center line *ab* of Fig. 1; draw the curved stops of the flutes freehand, and complete the figure.

DRAWING PLATE, TITLE: DORIC DOORWAY

14. This plate shows a plan, elevation, and vertical section of a stone doorway designed in the Roman-Doric order, and adapted to meet the requirements of modern work. The figures in this plate are all drawn to a scale of ¾ inch = 1 foot, and should be carried along together, so that details of one may be projected to another.



Scale
Parts
Modules
Fig. 2
Fig. 3
16 m.
14 m.
4 m. 20 p.
10 ft. or 16 m.

DORIC DOORWAY.

Begin with Fig. 2, the *elevation of the doorway*, and draw the center line ab at a distance of $5\frac{1}{8}$ inches from, and parallel to, the right-hand border line; then draw the floor line xy at right angles to ab, at a distance of 1 inch above the lower border line; the door opening being 5 feet wide, lay off 2 feet 6 inches on each side of the center line ab, and draw the jamb lines; then draw the head jamb lines of the door opening at a distance of 10 feet above the floor line. Dividing the width of the opening into 8 equal parts will give $7\frac{1}{2}$ inches as the measurement assigned for the module or semi-diameter of the column.

Construct the proportional scale of modules by drawing a line $\frac{3}{16}$ inch above the lower border line. Mark a distance of 3 feet 9 inches on this line, from a point $\frac{3}{4}$ inch from the left-hand border line; dividing this line into 6 equal parts will give $7\frac{1}{2}$ inches, thus making the scale 6 m. in length. Subdivide the first module into 6 equal spaces, each of which will represent 5 p., or $\frac{1}{6}$ m.

The scale of $\frac{3}{4}$ inch = 1 foot must now be laid aside, as all measurements, except those relating to the wooden door, the thickness of the walls, and the lathing and plastering, are given in modules and parts of a module.

Draw the center line lm of the column at a distance of 6 m. $7\frac{1}{2}$ p. from, and parallel to, the center line ab; then mark a series of points on the center line lm, representing the principal divisions of the order, beginning at xy, the floor line; mark a point, and draw the ground line at a distance of 24 p. below it; then, above it, mark, for the height of the plinth, 1 m. 28 p.; for the base of the column, 30 p.; for the shaft of the column, 14 m.; and for the capital of the column, 30 p.; for the architrave, 30 p.; and for the frieze and cornice, each 1 m. 15 p. Through these points draw the horizontal lines that define the members.

Now draw the line gh at a distance of 4 m. 20 p. above the top line of base cd, and on gh lay off 30 p. each side of the center line lm; draw the vertical lines down to the base parallel to the center line lm. Complete the profile of the base and plinth of the column as shown, the principal

dimensions being figured; others may be obtained by scale measurement. Draw the capital of the column, locating the neck lines 25 p. each side of the center line *l m*; draw the moldings under the neck of the capital down to line *e f*.

Draw the profile of the entablature as shown, the moldings being drawn freehand; lay off and draw the triglyphs on the frieze, the guttæ of the same on the architrave, and lay off and draw the dentils on the bed mold of the horizontal cornice.

To determine the pitch of the pediment, describe an arc from the point *p*, at the lower angle of the crown mold of cornice, with a radius equal to the length of the facia fillet *p r*, which is 17 m. 17 p., intersecting with the center line *a b*; from this point as a center, and with the same radius, describe the arc *p q r*; then, from the point *q*, with a radius equal to the depth of the cornice less the crown mold, describe the arc as shown; from the point *p*, and tangent to this arc, draw the line of the fillet below the crown mold; parallel to this line draw the lines of the crown mold from the angles of the horizontal molding; make the facia, fillet, and bed-mold members the same width as those of the horizontal cornice, measuring, however, on a line at right angles to the pitch line of the pediment; the dentils of the pediment cornice are immediately over those of the horizontal cornice, so that their position can be projected from them.

The column, entablature, and pediment having been drawn on the left of center line *a b*, duplicate the work to the right of the line, first drawing the center line of column *n o* and proceeding as before. This being done, draw the architrave around the door opening, and the piers situated behind the columns, as shown in Fig. 1; draw the plinth and base lines of the piers, and extend the entablatures over the piers.

Now draw Fig. 1, which is a *plan of the doorway* on the section line *g' h'*; first draw *c' d'*, the center or axial line of the columns, at a distance of $3\frac{1}{4}$ inches from, and parallel to, the upper border line; at a distance of 6 m. $7\frac{1}{2}$ p. to the left of center line *a b*, draw the center line of column; this line is a continuation of the line *l m*, from which it may be

projected; from the point of intersection of this line with the line $c' d'$, and with a radius of 30 p., draw the plan of the shaft. At a distance of 21½ p. from line $c' d'$, draw the face line of pier, and, at a farther distance of 30 p., the face line of the wall; draw the jamb line of the door opening and the return of the pier; draw the curves that represent the molded members of the base, the radii being procured from Fig. 2 by means of the compasses, with a center on the line $l m$; in a similar manner, transfer the measurements of the base and plinth blocks; locate and draw the architrave and the panel and molds of the jamb or reveal of the door opening. This being done on the left of the center line $a b$, the work may be duplicated to the right of this line.

Next draw Fig. 3, which is a *vertical section of the doorway* on the center line $a b$ of Fig. 1.

Begin by drawing the center line $l' m'$ at a distance of $1\frac{9}{16}$ inches from the right-hand border line; then project the horizontal lines of the order from Fig. 2, profile the column and entablature by measurements transferred from Fig. 2, working from the center lines of the columns of each figure; observe that the face of the panel of the pediment is in line with the faces of the architrave and frieze, and that the full lines which subdivide the cross-hatched area represent the size of the stones composing the structure. Draw the joint line of the jamb adjacent to the base of column, after which divide the distance between this line and the head jamb into 6 equal parts and draw the joint lines; then project these lines to the piers of Fig. 2. Draw the joint lines across the face of the pediment cornice and horizontal cornice, as shown on Fig. 2, observing that these lines are at right angles with their respective members; project the pediment cornice-joint lines on Fig. 2 over to Fig. 3.

To draw the flutings of the shafts, begin by drawing from t, the center of the left-hand column in Fig. 1, the diagonal lines $t s$ and $t u$, each at an angle of 45° from the axial line $c' d'$. By means of a protractor, divide the angle of 90° contained between these lines into 5 equal parts of 18° each, and draw the radial lines of division; the intersection

of these lines with the arc defining the shaft will give the *arrises* between the flutes.

To describe the curve of the flutes, set the bow-pencil to the chord of the arc between the angles of the flutes, and then from each angle describe an arc, as shown. The intersection of these arcs defines the center from which the curves of the flutes may be drawn with the same radius. One-third of the shaft having been filled in, the remainder can be drawn in a similar manner. The curves opposite the flutes represent the finish of the flutes on the apophyge at the base of shaft.

Having completed the plan to the left of the center line $a\,b$, draw the opposite one by the same process.

As the sides of shaft between lines $g\,h$ and $v\,w$, on Fig. 2, are perpendicular, and of the same diameter as shown on the plan in Fig. 1, the lines of the flutings of this section can be projected from Fig. 1. But, in order to determine points for the curved outlines of the flutings between lines $e\,f$ and $g\,h$, the semicircles that have been drawn on the lines $e\,f$, $3_1\,i$, $2_1\,j$, and $1_1\,k$, to profile the entasis, should be divided similar to the plan of shaft on Fig. 1.

Having marked the angles of the flutes on each semicircle, project the points by lines drawn parallel to center line $l\,m$, and intersecting with their respective base lines $1_1\,k$, $2_1\,j$, and $3_1\,i$. The points of intersection will give the desired points on the curved outline of each flute, through which, by the aid of a flexible strip, the curves may be drawn. The curved stops of the flutes at $e\,f$ and $v\,w$ can now be drawn.

Transfer the various points over to the column on the right of center line $a\,b$, and also to the column on Fig. 3, and complete the flutings.

The design having now been developed by means of the proportional scale and measurements, the drawing will be completed by means of the regular $\frac{1}{4}$ inch = 1 foot scale. Proceed to finish Fig. 1; draw the inner face line of the stone wall and the lines showing the furring strips and plastering on the inside of the wall; draw the door frame, which is 7 inches wide, and the door stops that cover the frame; draw

the door, which is $2\frac{1}{4}$ inches thick, and lay off the framing, moldings, and the panels, all of which are shown in section. The dimensions of the framing and moldings can be procured from Fig. 2. Observe that the door is in two leaves, the central joint being rabbeted. Draw the door elevation on Fig. 2 by projecting the vertical lines from Fig. 1; make the lower rail 14 inches wide, the lower panel $16\frac{1}{2}$ inches high, each of the lock-rails $3\frac{3}{4}$ inches wide, and the lock-panel 6 inches wide. Draw the raised and ornamental panels as shown; run a series of vertical and horizontal lines to locate the center of the studs on the door framing, and from the centers found describe the circles. Draw the escutcheon adjacent to lock-panel, in which is placed the Yale key cylinder and the door knob. The drawing can now be inked in, crosshatched where shown in section, the dimension and center lines drawn, and the dimensions neatly written. The reference letters may be omitted.

Any dimensions taken on the drawing with the scale of $\frac{3}{4}$ inch = 1 foot will give the working measurements, and it should be so figured if required for a working drawing.

DRAWING PLATE, TITLE: RENAISSANCE DOORWAY

15. This plate shows a design for a rich stone doorway in the Renaissance style, drawn in elevation and section to a scale of $1\frac{1}{2}$ inches = 1 foot.

Commence the *elevation* by drawing the center line $a\,b$ at a distance of $8\frac{1}{2}$ inches from, and parollel to, the left-hand border line, and draw $c\,d$, the floor line, at a distance of $\frac{5}{16}$ inch above the lower border line.

As the door opening is 5 feet 6 inches wide, each reveal line will be 2 feet 9 inches from the line $a\,b$; draw the soffit line at a distance of $7\frac{3}{8}$ inches above the lower border line.

The height of the opening is 11 feet, or twice its width as marked, but only the upper and lower portions of the jambs are shown, as indicated by the broken or irregular lines.

The development of the design is based on a standard of proportion, of which the *module* is the unit of measure, as explained in the directions for drawing the orders. To establish the module in this example, divide the width of the opening into 10 equal parts, thus getting $6\frac{6}{10}$ inches as the module.

Draw the *proportional scale* where shown; mark a distance equal to one-half of the width of the door opening, and divide it into 5 equal parts, each of which will equal 1 m., and subdivide the first division of the scale into 30 parts, as shown. The scale of $1\frac{1}{2}$ inches = 1 foot should now be laid aside, as all subsequent measurements are given in terms of the proportional scale of modules. Proceed with the elevation to the right of the center line *a b*, completing as far as practicable one half of the figure before starting the other half.

Starting at the floor line, mark a series of points on the line *a b*, defining the heights of the plinth, base, and capital of the semi-column, and of the architrave, frieze, and cornice of the entablature; through these points draw horizontal lines.

Subdivide these members by a series of points, defining the position of their respective details, and draw the horizontal lines. At a distance of 1 m. 15 p. from the jamb line *e f*, mark the width of the architrave, and at a farther distance of 30 p. mark the width of the semi-column; then from these points draw the vertical lines.

Profile the molded section of the column and entablature as shown; draw *e g*, the miter line of the architrave, and, from the points of intersection of the horizontal lines with this line, draw the lines of the vertical members of the architrave; mark the points of subdivision of the architrave base block, and draw the lines. Draw the center line of the second facia of the architrave at a distance of 25 p. from the jamb line; locate the centers for the **pateræ**, or rosette-like ornaments, and with a radius of 5 p. describe the circles.

To draw the dentils in the bed mold of the cornice, divide the line *a' h* into 49 equal parts, two of which will belong to each dentil, and one part to the channel between them.

Now draw Fig. *A*, which is a *transverse section of the jamb*

on line *i j*, looking downwards; draw *k l*, the wall line, at a distance of 4$\frac{3}{16}$ inches above the lower border line, and from the elevation project the lines of the architrave base block and the plinth and base lines of the column, and complete the section as shown.

Repeat the system followed in drawing the right-hand section of the elevation, on the left of center line *a b*. Draw Fig. *B*, which is a *transverse section of the jamb* on line *m n*, looking upwards, showing the plan of the capital, the leaves being omitted to prevent confusion. Locate *o p*, the wall line, at a distance 2$\frac{1}{4}$ inches from the lower border line; from the point *r* draw the diagonal line *q r* at an angle of 45°, and equal in length to the line *r p*; draw the line *q u* at right angles to *q r* and mark the point *u*; draw *q s* parallel to *o p*. From *q* as a center, with a radius equal to twice the length of *q s*, describe an arc intersecting with the line *o p* produced; from this point of intersection as a center, describe the curve *u v*, which is the edge of the abacus; draw the opposite edge in the same manner, first locating a center for the curve on the outer edge of the architrave by means of an arc described from the point *q*; draw the parallel lines defining the molded members on the edges of the abacus, but omit the volute on the plan until it has been drawn on the elevation.

In order to draw the leaf ornament on the cyma-reversa moldings of the cornice, the center lines of the channels between the dentils should first be drawn. Observe that the width of each leaf of the lower molding occupies the full distance between these center lines, while in the upper cyma-reversa molding two leaves occupy the same space, so that on the upper molding there should be double the number of divisions shown below.

Having spaced off the length of the cornice to the left of the center line, sketch in a series of the leaf forms on both upper and lower moldings, and also the *pearl-and-bead* ornament of the upper molding as far as the line *a' b'*; then on a piece of tracing paper make a copy of the ornament in pencil, and transfer it to the adjacent section, as explained before.

Draw the *egg-and-dart* ornament on the bed molding of

cornice by the same method, observing that the center of each division of the ornament is immediately below the center of each dentil.

From the centers of the pateræ on the facia of the architrave, project a series of lines to the outer molding, observing that the distance between these lines is occupied by three leaves of the ornament on the molding. Sketch in a series of the leaves, and transfer by the method followed above; then draw in the leaves of the inner molding, as shown.

In order to establish the governing lines of the foliage and the volute of the capital, divide the height of the bell into 6 equal parts, and through the points of division draw horizontal lines; then draw five vertical lines, making the distances between them equal to the spaces between the horizontal lines, thus resolving the area into a series of squares.

Note carefully the points where the curved lines of the ornament intersect with the lines of the squares on the plate, and mark similar points on the drawing; these points will act as guides to the correct location of the curves, which should be sketched in lightly at first, and then strengthened; after which the design may be transferred to the opposite side by means of a copy on tracing paper. Draw the ornament at the end of the frieze in a similar manner, first dividing the height between members into 4 equal parts and constructing squares as before. The volute on Fig. *B* may now be sketched in, first drawing a series of vertical lines down from the volute on the elevation, so as to define the principal points governing the roll of the spiral, after which the drawing should be carefully compared with the plate and completed.

DRAWING PLATE, TITLE: DOOR AND WINDOW TREATMENT

16. This plate shows a Gothic tracery window of four *days*, or openings, and a modern Romanesque doorway, both of which are drawn to a scale of $\frac{1}{2}$ inch = 1 foot.

Commence Fig. 1, which is the ***elevation of the window,***

DOOR AND WIND

Fig 1.

DOW TREATMENT.

ale = 1 ft.

by drawing the center line *a b* at a distance of $4\frac{1}{16}$ inches from, and parallel to, the left-hand border line; then draw the line *c d*, which is the springing line of the tracery, at a distance of $5\frac{1}{4}$ inches from, and parallel to, the lower border line.

The width of the window opening in the clear being 10 feet 10 inches, lay off one-half of this width on each side of the center line *a b*, and draw the reveal lines; from each reveal line lay off 15 inches, the width of the moldings on the jamb, and mark the width of each member of the moldings; then draw vertical lines down to the sill; locate the central and intermediate **mullions**, or vertical shafts, between the days of the window, in accordance with the figured dimensions, and draw the vertical lines down to the sill.

The tracery in the upper part of the window is based entirely upon a geometric system of construction, and its governing lines can be drawn without any other dimensions than the widths of the window and of its central mullion between certain established center lines. These center lines are taken through the middle of the fillets on the jambs and mullion of the window, as shown in Fig. 1 at *e g h* and *j*.

On the line *c d*, lay off on each side of the center line *a b* a distance of 5 feet $7\frac{3}{4}$ inches, thus locating the points *e* and *j*; and also lay off on each side of *a b* a distance of $2\frac{5}{8}$ inches, thus locating the points *g* and *h*. Now from *e* and *j* as centers, and with a radius *e j*, or 11 feet $3\frac{1}{2}$ inches, describe two arcs intersecting at *m*, and through their point of intersection draw a horizontal line, which will be the center line of the fillet at the top of the window head, as shown at *f*. Now, on *e*, *g*, *h*, and *j* as centers, and with a radius equal to *e g*, or 5 feet $5\frac{1}{8}$ inches, describe arcs intersecting at *p* and *q*; bisect *e g* and *h j* at *f* and *i*, and on *e* and *j* as centers, with a radius equal to *f j*, or 8 feet $6\frac{15}{16}$ inches, describe arcs intersecting at *r*. Now on *r* as a center describe a complete circle tangent to the arcs *j m* and *e m*. This circle will have a radius of 2 feet $8\frac{11}{16}$ inches, and should come within $4\frac{3}{4}$ inches of the arcs *g p* and *h q*. Now with this same radius, and on

e, *f*, *g*, *h*, *i*, and *j* as centers, describe eight arcs intersecting at *k*, *l*, *s*, and *t*; and with these four points of intersection as centers, describe four arcs intersecting at *p* and *q*; and from *p* and *q* as centers, describe the two arcs *k l* and *s t*. Now through *e* and *j* draw perpendicular lines to the top of the window, and the skeleton outline of the tracery is complete.

Now draw the cusps of the small arches under the arch *h q j*. From the centers *s* and *t* draw vertical lines down to the springing line *c d*, and locate the center *u*; then with a radius of $8\frac{1}{2}$ inches describe a circle; locate the centers *v*, *w*, and *x* as shown, *v* and *w* being at the intersections of the circumference of the circle with two vertical lines drawn $6\frac{15}{16}$ inches each side of the center line, while *x* is at the intersection of the circumference with the center line itself; from these points, with a radius of $6\frac{3}{8}$ inches, describe the inner lines of the cusps; from points *h* and *i* describe the rib curves which are parallel to these cusp curves; locate similar centers for the cusps under the arch *i t j*; draw the cusps and then the rib curves as before. To determine the center of the spherical triangle *s q t*, bisect the angles *q s t*, *q t s*, and *s q t*, and the intersection of these bisecting lines at *y* will be the center required. From *y* as a center, with a radius of 8 inches, describe a circle; within this circle draw an equilateral triangle, by joining the points of intersection of the circle with the bisecting lines; from each vertex of this triangle as a center, with a radius of $5\frac{5}{8}$ inches, draw the curves of the cusps; complete the trefoil by drawing the parallel rib curves from the centers *s*, *q*, and *t*, and draw the moldings composing each rib; the small spandrels adjacent to the cusps are called *eyes*, and are panels cut in the face of the rib to lighten its appearance, but are not cut entirely through the stonework, as are the days.

Draw the cusps which form the **quarterfoil**, or four-leafed figure, in the circular section of the window; from the center *r*, with a radius of $18\frac{1}{16}$ inches, draw a circle; through *r* draw a vertical and a horizontal line; the intersection of these lines with the circle just drawn will define the centers from which arcs may be struck to form the cusps; draw

diagonal lines from these points, which will define the length of the cusps, and complete the figure, as shown.

To draw the tracery of the large spandrels, first locate the center *z* according to the measurements given; from *z* as a center, with a radius of $16\frac{3}{8}$ inches, describe a circle, which will be the center line of the circular rib; draw another circle from the same center with a radius of 8 inches, as shown in the right-hand spandrel, and inscribe an equilateral triangle, as shown; then from the vertices of this triangle as centers, and with a radius of $5\frac{5}{8}$ inches, describe the curves of the cusps forming the trefoil, and complete the figure, as shown.

From the point c' as a center, with a radius of 3 feet $11\frac{1}{2}$ inches, describe the arc $d'e'$; bisect this arc, establishing the center a', from which, with a radius of $2\frac{3}{4}$ inches, the small circle may be drawn; draw the center line of the cusps which radiate from it; then draw the cusps themselves.

From the center *z*, with a radius of 2 feet, describe the arc $f'g'$; bisect the arc and establish a center at b', from which, with a radius of $2\frac{1}{4}$ inches, describe the small circle; draw the center line of the cusps that radiate from it, and draw the cusps as before; then complete the tracery throughout. Draw the hood molding over the window, first locating the horizontal lines and then drawing the profile.

Draw $h'i'$, the bed line of the window sill, at a distance of $\frac{9}{16}$ inch above the lower margin line; then draw the top line of sill $21\frac{3}{4}$ inches above this line; draw the lines of the drip mold of sill adjacent and parallel to line $h'i'$; draw the profile of the jamb molds and mullions, which detail, or describe, their outline, on the sloping surface of the sill; the line $j'k'$ is the line of intersection of the slope with the vertical face of the wall at the sides of the window.

The continuity of the jamb molds and mullions is broken by the irregular lines that separate them, indicating that the total height of the window is not shown; this height would be from 4 feet to 6 feet greater.

Now draw Fig. 4, which is a *plan of the jamb of the Romanesque doorway* taken on the line *n o* of Fig. 2. Begin by

drawing the vertical center line *a b* at a distance of 4$\frac{15}{16}$ inches from, and parallel to, the right-hand border line; then draw *l m*, the face line of the wall, at right angles to *a b* and at a distance of 3$\frac{3}{8}$ inches below the upper border line; the width of the doorway being 7 feet, the position of *j k*, the reveal line, will be 3 feet 6 inches from the center line *a b*.

From *j k* lay off the lines representing a series of three reveals; receding from the door opening, the first is 3$\frac{3}{4}$ inches from *j k*, the second and third each at farther distances of 15 inches; from *l m* lay off the horizontal lines representing the receding face lines, three being at distances of 15 inches apart, and the inner one at a distance of 3$\frac{1}{4}$ inches; locate the centers of the shafts and draw their plans, with a radius of 6 inches, as they are each 12 inches in diameter.

Draw the outer curves from the same centers, indicating the members that compose the bases; then draw the angular line showing the edge of the plinth block on which the bases of the shafts rest.

Next draw Fig. 3, which is a *plan of the arch moldings* taken on the springing line *g h* of Fig. 2. Draw *j' k'*, the reveal line, at a distance of 3 feet 6 inches from the center line *a b*; locate the angles of the recessions by the measurements given, and draw the angle and face molds and the line of the abacus on top of the capitals of the columns.

Now proceed with Fig. 2, the *elevation of the doorway*. Draw the ground line *c d* at right angles to center line *a b*, and at a distance of $\frac{9}{16}$ inch above the lower border line; at a height of 9 feet 8 inches above the line *c d*, draw *e f*, the impost line; then draw *g h*, the springing line, at a distance of 10 inches above the line *e f*.

From the point *i* as a center, with a radius of 3 feet 6 inches, draw the curve *j'' k j'''*; from *j''* and *j'''*, the points of intersection of this curve with the line *g h*, draw the vertical reveal lines of the door opening.

From the point *j''*, on the line *g h*, mark the width of the various arch members, in accordance with the measurements given; from point *i*, with radii extending to these points, draw the curved lines as shown.

From the line $c\,d$, on the center line $a\,b$, mark a series of points locating the vertical measurements of the plinth course and the bases of the shafts, and through these points draw horizontal lines; then, from the line $e\,f$ on the center line $a\,b$, mark a series of points representing the vertical measurements of the capitals of the shafts, and through these points also draw horizontal lines.

From Fig. 4 project the shafts and base lines, and repeat them on the opposite jamb; then draw the moldings of the capitals and bases.

As the ornament on angle mold A and on the facias B and C is composed of repeated sections, it will only be necessary to draw one section of each correctly, which can be transferred and duplicated on the adjacent sections, and the operation continued until one-half of the arch has been occupied, as shown.

Divide the inner curve of the angle mold A, from the line $g\,h$ to the center line $a\,b$, into 17 equal parts, and mark the points 0, 1, 2, 3, 4, 5, 6, 7, etc.; then, from each of these points, with the dividers set to 4½ inches, mark a second series, as 0_1, 1_1, 2_1, 3_1, etc.

From the center i, draw radial lines through these secondary points, and mark their intersections with the outer curve of A, as 0_{11}, 1_{11}, 2_{11}, 3_{11}, etc.; then draw the lines 0–0_{11}, 1–1_{11}, 2–2_{11}, 3–3_{11}, etc.; on each of these lines draw a reversed curve, as shown, representing the center line of the reeded strap between the leaves.

Now, on the right-hand side of the center line $a\,b$, divide the angle mold A, the same as has been done on the left side; this done, draw freehand a series of three or four straps and leaves, sketching them very faintly and finishing them with a clean, even line; then, on a small piece of tracing paper, carefully trace the form, and on the back of the tracing paper rub a soft pencil, thus forming a transfer paper. Transfer the copy to the adjacent section, carefully observing that the center lines of the bands are over those already drawn; and trace over the form of the figure with a hard pencil, which will transfer the lead on the back of the tracing to the

surface of the drawing, giving the outline of the figure, which should then be strengthened with a hard pencil. Continue this operation until the ornament on one-half of the molding is completed.

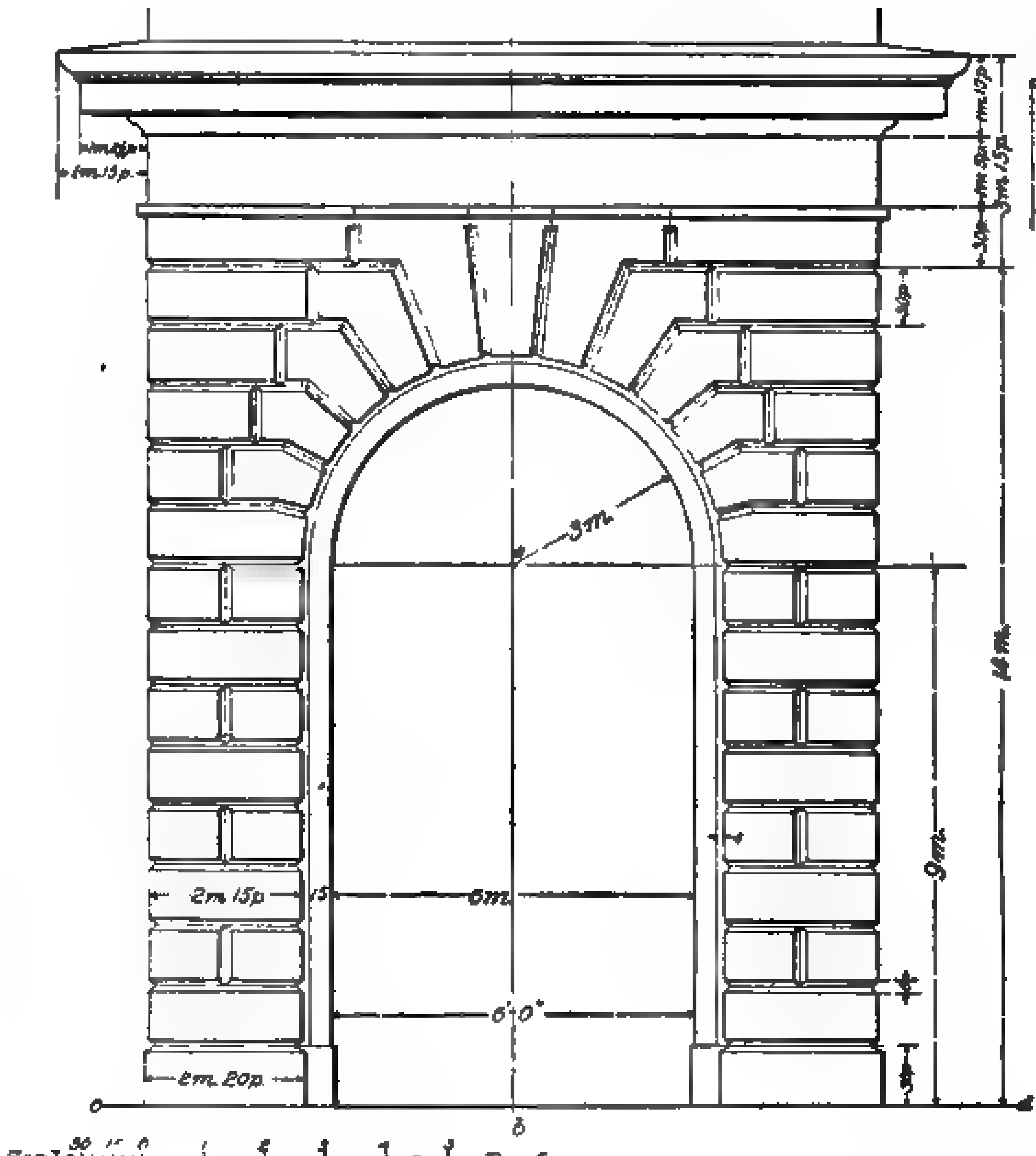
In order to locate the sections of the ornament on facia *B*, divide the inner curve of the quadrant from line *g h* into 16 equal parts, as *8*, *9*, *10*, *11*, *12*, etc.; and repeat the divisions on the right-hand quadrant; then draw freehand four or five sections of the ornaments, carefully outlining the ribs and leaves, taking care to make a neat rendering, which may then be traced and transferred, as explained above.

To draw the ornament of facia *C*, divide the outer curve of the quadrant into 10 sections, as *13*, *14*, *15*, *16*, *17*, etc.; repeat the divisions on the right-hand quadrant, and draw freehand four or five sections of this ornament, taking care to make the curves of the tendrils easy and graceful, and then transfer them as before. Draw the chevron ornament on the chamfer of the hood mold, as shown.

Draw the guilloche ornament on the chamfer of the abacus, making the angle of the interlacing reeds 45°; then draw freehand the scroll formed by the fillet of the abacus.

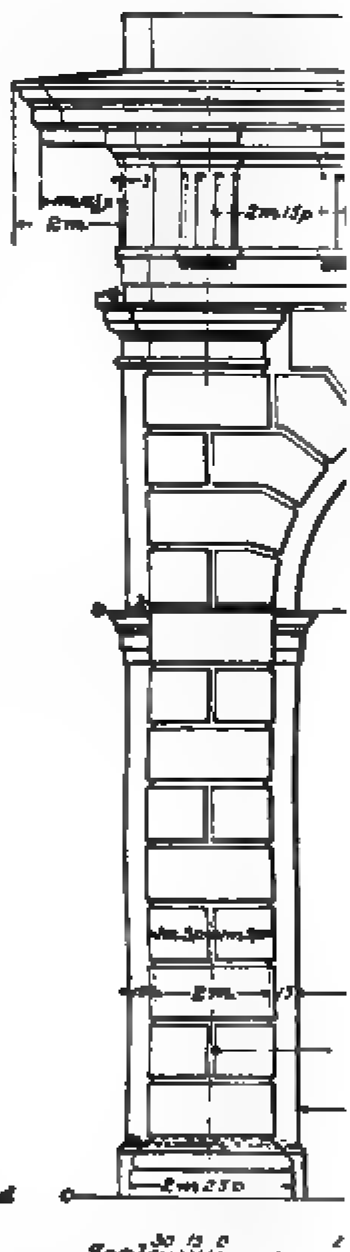
Draw the angular stalk represented by the rib lines which are united by the reeds at the collar of the shaft. Draw the leaf growing out of the stalk, forming the veins by graceful curves, and giving the lobes a sharp and angular outline, which is characteristic of this style.

Next draw the capitals, outlining the tendrils, which finish in a foliated cluster at the angle of each capital. Observe that the tendrils start near the center of the shaft and form well-defined lines as they approach the cluster. Sketch them first very faintly, and endeavor to obtain graceful, easy curves, as they form the growth line of the design from which the leaves branch; draw the ribs of the leaves, and arrange their lobes as near the position shown on the drawing as possible.



2m.15p.
2m.15p.
3m.
9m.
14m.
6m.
6' 0"
2m.20p.
Scale
Parts
Modules

Fig 5



2m.15p
2m.
2m.25p
Scale
Parts

...NT IN DESIGN

Fig. 3

Fig. 4

Fig. 6

Fig. 8

DRAWING PLATE, TITLE: EXAMPLES IN DESIGN

17. This plate illustrates a number of *architectural details* in the Gothic and Renaissance styles.

Figs. 1, 2, 3, and 4 are Gothic details, drawn to a scale of $1\frac{1}{2}$ inches = 1 foot. Figs. 5 and 6 are Renaissance doorways, drawn to a proportional scale. Figs. 7 and 8 are Romanesque or early Gothic details, drawn to a scale of $\frac{3}{4}$ inch = 1 foot.

Begin Fig. 1, which is an *elevation of a decorated panel*, by drawing the center line *a b* at a distance of $2\frac{1}{16}$ inches from, and parallel to, the left-hand border line; draw *c d*, the horizontal center line of the panel, at a distance of $2\frac{9}{16}$ inches below, and parallel with, the upper border line; from the center *d*, with a radius equal to one-half the side of the panel, which will be 1 foot-$3\frac{1}{2}$ inches, describe arcs intersecting the vertical and horizontal lines; through the points of intersection draw the lines defining the sides of the square.

From the center *d*, with the radii given, describe the lines of the circular molding; from the measurements given, locate the centers of the small trefoil panels in the corners; from each center, with a radius of $2\frac{1}{8}$ inches, describe a circle; then, with a radius of $1\frac{3}{4}$ inches, describe an inner circle; within the inner circle draw an equilateral triangle, as shown. Within this triangle inscribe a circle, from the center of which draw lines to the vertices; the intersection of these lines with the inner circle will define the centers for the **foils**, or leaf-like spaces, between the **cusps**, or spear points, formed by the circles composing the foils. By increasing the radius $\frac{3}{8}$ inch, the molded edge of each cusp may be drawn.

In drawing the foliage of a figure, where each half is symmetrical, it is more expedient to sketch one-half of it in outline, showing only the governing lines, which, being satisfactorily drawn, will simplify the execution of the finer detail. This system is followed in Figs. 1, 2, 3, and 4, as it tends to give the student a clearer idea of the composition. It will be necessary, however, to locate carefully several points defining the relative position of each leaf of the group.

Beginning with leaf *A*, of Fig. 1, locate the points *e, f, g,*

and *h* by the measurements given, and connect these points with the dotted outline. From points *g* and *h* draw horizontal lines defining the space occupied by the upper portion of the leaf *B*; the center line *c d* will give the relative position of the lower portion of this leaf. From the center line *c d*, locate and draw the horizontal lines that limit the outline of the lower leaf *C*. Returning to leaf *A*, draw freehand, in faint outline, the **lobes**, or divisions, of the leaf. In drawing the foliage, the student should try to obtain easy and graceful curves, and, when satisfactorily drawn, he should strengthen the lines, using an irregular curve where practicable.

Now draw freehand the upper line *i j k* of leaf *B*, always drawing the curves downwards, as from *j* to *i*, then from *j* to *k*. Draw the scalloped edge of the lobes, and from the points *q* and *r* draw the curved edges of the lobes that unite tangentially with the upper line *i j k*, drawing from the line *i j k* downwards to the scallop; then sketch the stem lines, until they die in the stalk. Draw the upper line *l m n* of leaf *C*, drawing from *m* to *l* and from *m* to *n*. Then draw the scalloped edging and the curved edges of the lobes that unite with the line *l m n*, and draw the stem line *o p*, sketching from *o* to *p*.

Having satisfactorily drawn the outline of the leaves on the left side of the figure, proceed in a similar manner with the right side; then finish the various details of the leaves, and draw the grapes as shown.

Proceed with Fig. 2, which is an *elevation of a gable finial*, decorated with foliated **crockets**, or bent branches, over which the leaves are laid. Draw the center line *a b* at a distance of $6\frac{11}{16}$ inches from, and parallel to, the left-hand border line, and draw the line *c d* of indefinite length, at a distance of $5\frac{1}{4}$ inches from, and parallel to, the upper border line. Draw the line *e f* at a distance by scale of 20 inches above the line *c d*; then locate the point *f* at a distance of 2 feet $\frac{1}{8}$ inch from the center line *a b*; from *f* as a center, with a radius of 2 feet $\frac{1}{8}$ inch, describe the curve *g h*, defining the top line of the molding; and from the same center draw the

parallel lines of the various moldings of the coping, the upper face of which is worked $\wedge$-shaped, and, being drawn together at the top, forms a lozenge-shaped section at the neck of the trefoil head.

To draw the curves on the left of the center line *a b*, produce the line *e f* over to the left-hand side, on which locate the center in the same relative position as the center *f*; then draw the curve of the gable and the trefoil head of the finial. Now outline the foliage on the left side of the figure; first draw a series of horizontal lines in accordance with the measurements given; then locate the points *i*, *j*, *k*, *l*, and *m* of the enclosing figure of leaf *A*, and also the points *n*, *o*, *p*, *q*, and *r* of the enclosing figure of leaf *B*. Sketch faintly the outline of each lobe of the leaves, uniting them by looped curves, as shown, and strengthening the lines when satisfactorily drawn; then draw the vein lines of each lobe, and the outline of the sprigs. Having finished the left-hand side, repeat the design to the right of the line *a b*, and then finish this side in detail as shown.

Proceed with Fig. 3, which is similar to Fig. 2, except the crockets, which have a different form of foliage. Draw the center line *a b* at a distance of $10\frac{3}{4}$ inches from, and parallel to, the left-hand border line; draw the line *s t* at a distance of $19\frac{1}{2}$ inches, by scale, above, and parallel to, the line *c d*; locate the center *s* at a distance of 1 foot $10\frac{1}{4}$ inches to the left of center line *a b*, and draw the curves of the coping molds; produce the line *s t* to the opposite side, on which locate the center, from which the curves may be drawn; then draw the inclined lines that converge towards the top of the finial, and draw the trefoil head of same. Now draw the outlines of the foliage on the left side of the figure, locating the points of the enclosing figure of each leaf by means of the horizontal lines and measurements given, drawing the outline of the foliage and sprigs; then repeat them on the adjacent side, as directed by the preceding figures.

Commence Fig. 4, which is an elevation of a *Romanesque* or *early Gothic capital.* Draw the center line *a b* at a distance of $2\frac{7}{16}$ inches from, and parallel to, the right-hand

border line; draw $c\,d$, the top line of the abacus, at a distance of $\frac{5}{8}$ inch below the upper border line. From the line $c\,d$, mark a series of points on the center line $a\,b$, locating the divisions of the capital; then, from the dimensions given, draw the profile of the moldings and the body of the left side of the capital. Now draw the foliage, first locating the points $e, f, g, h, i, j, k, l, m$, and n, defining the tips of the leaves and the intersection of the stem lines. This done, commence on the foliage by drawing from p' to i; then from g to i; from f to q; from f to o; from o to j'; from j to j'; from o' to n; and from e to n. Draw from p' to p; from g to h; from q' to q; from o' to o; from h to i'; from h' to e'; then from e to e' draw the loops defining the overlaps at g and q, which completes the outline of the upper section of the foliage.

Draw from j to k; then draw the lines $m\,l$, $j\,j'\,l$, $m\,m'$, $m'\,r$, and finish by drawing the stem lines. This done, repeat the operation on the opposite side, and complete the details as shown.

Begin Fig. 5, which is an *elevation of a Renaissance doorway*, by drawing the center line $a\,b$ at a distance of $3\frac{3}{16}$ inches from, and parallel to, the left-hand border line, and draw $c\,d$, the ground line for Figs. 5 and 6, at a distance of $\frac{9}{16}$ inch above the lower border line.

The door opening is 6 feet wide, and should be laid down to a scale of $\frac{3}{8}$ inch = 1 foot. This done, divide the width into 6 equal parts, one of which will determine the *module*, or unit of proportion.

Draw a scale of modules as shown, making its length equal to the width of the door opening, which, divided, will define the modules. Subdivide the first one into 6 equal spaces, each of which will represent 5 p.

At a distance of 9 m. above the ground line, draw the springing line of the arch, and from the center e, which is located on the center line $a\,b$, with a radius of 3 m., describe the *soffit* line, or under side, of the door opening; on the springing line, mark the position of the jamb and pier lines, and describe the curves from the center e.

From the intersection of the curves with the springing line, draw the vertical lines to the ground line *c d*; on the center line *a b* mark a series of points defining the horizontal lines of the entablature and the course that surmounts it. Divide the distance between the ground line and the architrave into 14 equal courses of 1 m. each, and draw the horizontal joint lines; divide the soffit line of the arch into 13 equal parts, and draw the joint lines radiating from the center *e*.

Locate and draw the vertical joint lines, then mark the width of the **chamfer**, or splayed edge of the courses, which is 3 p. on each side of the joint line. Draw the lines and show the cut of the chamfer, which has a bevel of 45°, as shown on the returns. Draw the profile of the entablature and finish the figure.

Begin Fig. 6, which is also an *elevation of a stone doorway of the Renaissance style*, by drawing the center line *a b* at a distance of $9\frac{1}{16}$ inches from, and parallel to, the left-hand border line.

The opening is 6 feet wide, and should be laid down to a scale of $\frac{3}{4}$ inch = 1 foot. This done, divide the width into 7 equal parts, one of which will determine the module.

Draw a scale of modules as shown, making its length equal to the width of the door opening, subdividing the first one into 6 equal spaces, each being 5 p.

At a distance of 10 m. and 15 p. above the line *c d*, draw the springing line of the arch; from the center *e'*, with a radius of 3 m. 15 p., describe the soffit line of the door opening; then, with a radius increased to 4 m., describe the soffit line of the outer arch; from the intersection of the arch lines with the springing lines, draw the vertical reveal lines; on the springing line, mark the width of each *pilaster* and pier, and also the position of center line of each pilaster, and draw the vertical lines.

At a distance of 16 m. above the line *c d*, draw the lower line of the entablature; then, at a distance of 4 m. above this, draw the upper line of the entablature; divide the entablature into architrave, frieze, and cornice, according to

the measurements given, and subdivide these members into their respective details by measurements taken from the scale, and draw the horizontal lines. Draw the profile of the entablature, observing that the frieze and lower facia of the architrave are in line with the neck of the capital and the return line of the pier; draw the triglyphs in the frieze, the guttæ on the architrave, and the mutules under the corona, as shown.

Draw the horizontal lines and profile the members of the capitals and bases of the pilasters and piers, locating the subdivisions by means of measurements taken from the scale on the plate.

Draw *g h*, the bed line of the first course above the base of the pilaster; in order to locate the courses composing the pilaster up to the top of the impost or springing line *e f*, mark a point on the center line of each pilaster 2 p. above the line *e f* and draw the line *k l*, this measurement being one-half of the width of the channel or groove between the courses; then mark a point at a distance of 2 p. below the line *g h* and draw the line *m n*; divide the vertical distance between the lines *k l* and *m n* into 9 equal spaces, which will define the center of each channel.

Lay off 2 p. on each side of these centers, and draw the lines of the *rustic*, or projecting portion of each course, as shown.

Bossage, or **rustic work**, is a style of ashlar masonry in which the joints are worked so as to form grooves or channels, which may be rectangular, as shown in Fig. 6, or beveled, as shown in Fig. 5. There are several variations of this style of masonry, all of which are intended to give an appearance of bold-relieved surface and massive effect.

Mark a point 2 p. above the line *i j*, and divide the distance between this point and the line *k l* into 4 equal parts; then space the channels and draw the rustic lines; divide the soffit line of the arch into 13 equal parts; from the center *e*, through the points marked, draw radial lines, on each side of which mark one-half the width of the channel, or 2 p., and draw the rustic lines parallel to the radial lines, intersecting

with the horizontal channels, as shown. Draw the horizontal lines and profile the members of the moldings composing the imposts of the piers, by means of scale measurements; draw the vertical lines of the rustic work and complete the figure.

Commence Fig. 7, which is an *elevation and section of a Norman or early Gothic parapet*, drawn to a scale of $\frac{3}{4}$ inch = 1 foot, by drawing the *section* to the left, which is taken on the line *c d*.

Draw the line *a b* at a distance of $3\frac{3}{4}$ inches from, and parallel to, the right-hand border line; draw *a'a*, the top line of the parapet, at a distance of $6\frac{3}{4}$ inches above the lower border line. From the line *a'a* mark a series of points defining the vertical position of the members, and through these points draw horizontal lines; then draw the profile in accordance with the measurements given.

From the section project the horizontal lines over to the elevation; draw the vertical line *c f* at a distance of $\frac{3}{4}$ inch from the right-hand border line, and draw the vertical line *c d* at a distance of 3 feet $8\frac{1}{2}$ inches by scale from the line *c f*. Locate the centers for the lower arches and draw them, and subdivide the arch mold into *billets*, or short sections, as shown. Draw the *chevron*, or zigzag, mold of the lower facia, and the scalloped edge of the second facia, which overlaps it.

Draw the **dog-tooth** ornament, which is a four-leaved ornament, having the center projecting, and finishing in a point, as shown. First draw the ornament in position on the section, projecting the several points over to the elevation; then complete both figures.

Now draw Fig. 8, which is an *elevation and section of a Norman arcade*, drawn to a scale of $\frac{3}{4}$ inch = 1 foot. Begin the section, which is taken on the line *i j*, by drawing *g h*, the face line of the wall, in line with the wall face of the section of Fig. 7, and draw *m n*, the bed line of the sill mold, at a distance of $\frac{11}{16}$ inch above the lower border line; on the line *g h*, mark the points defining the vertical position of the various members, and draw horizontal lines; draw the shaft,

base, and cap in position, as shown, and profile the molded courses and arch mold, and project the horizontal lines of the section over to the elevation; draw the vertical line *k l* immediately under the line *e f* of Fig. 7, and draw the line *i j* at a distance of 3 feet 5¼ inches from the line *k l*; locate and draw the center lines of the columns and arches. Profile the columns and draw the arch molds; locate and draw the *ball ornament* and the *lozenge ornament* on the face of the molded string-course surrounding the arches, and complete the figure.

DRAWING PLATE, TITLE: GOTHIC ARCADE

18. This plate shows a French Gothic arcade, drawn to a scale of 1½ inches = 1 foot.

Commence with Fig. 1, which is a *plan of the pier* on line *q r*, looking downwards; draw the center line *a b* at a distance of $2\frac{7}{16}$ inches from, and parallel to, the left-hand border line; draw *g h*, the wall line, at right angles to line *a b* and at a distance of $1\frac{7}{16}$ inches below the upper border line. Locate the centers of the shafts, and draw the circles defining the shafts with their bases—the measurements of the details being given on Fig. 2, from which the plan can be drawn and completed.

Proceed with Fig. 2, the *elevation of the arcade*, by drawing the vertical center lines *c d*, *e f*, and *c′ d′* at their respective distances from, and parallel to, the center line *a b*. Draw *i j*, the floor line, at a distance of $\frac{7}{16}$ inch above the lower border line, after which mark a series of points on the line *c′ d′*, locating the principal horizontal divisions of the design; thus, at a distance of 11 inches above *i j*, mark a point denoting the top of the base; at a farther distance of 3 feet 5 inches, the top of the shaft; then 10½ inches for the capital; 4½ inches for the impost; 8¾ inches to *k l*, the springing line for the main arches; 15¼ inches to the line on which the centers of the quarterfoils are located; 21½ inches to the bed line of the molded and decorated course; and 8¾ inches to the top line of the course; through these points draw

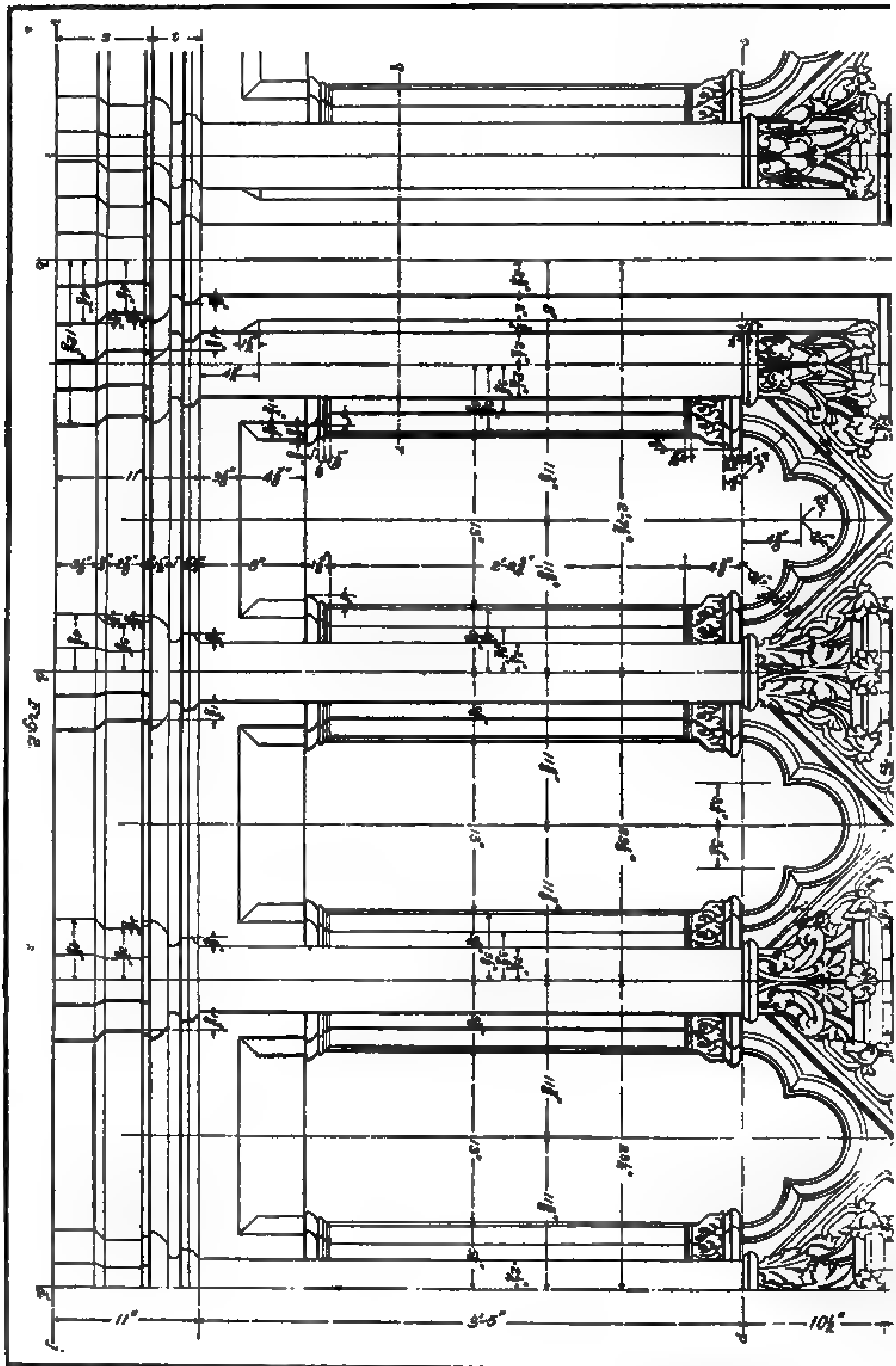


Fig. 2

GOTHIC ARCADE.

horizontal lines, and subdivide these principal divisions, defining the molded members and facias composing them.

From Fig. 1 project the pier and shaft lines to Fig. 2; from the lines just drawn, mark the limits of the bases of the shafts and profile the bases freehand. The upper portion of the base, marked *t*, is circular on plan, as shown on Fig. 1, while the plinth, marked *s*, is octagonal. As the outline of the lower section of the plinth is shown on Fig. 1, the angles can be projected therefrom. By drawing another line on the plan, nearer the center of the pier, and at a distance of $\frac{3}{4}$ inch from, and parallel to, the outline, the angles of the upper section of the plinth can be established, from which lines can be projected down to Fig. 2.

The diameter of the shaft, of which *e f* is the center line, being the same as that of the large angular shafts just drawn, the base and plinth lines can be transferred from it.

In order to draw the angular lines of the plinths under the $4\frac{1}{2}$-inch shaft, of which *c d* and *c′ d′* are the center lines, it will be necessary to draw a plan of the plinth under the elevation, locating the center of the shaft on the line *c d*; then with a radius of $3\frac{3}{8}$ inches draw a circle. From the same center, with a radius of $4\frac{3}{8}$ inches, draw a second circle; tangent to each circle draw a semi-octagon, the face of which will be at right angles to the center line *c d*; the angular lines on the elevation can then be projected from the plan so drawn.

Profile the moldings of the capitals, which are circular on plan, and of the impost blocks on the top of the capitals, which are octagonal on plan. First draw the projection of the top and bottom fillets on each side of the center line, from which the position of the other line can be determined; take, for example, the impost block of the shaft, whose center line is *c d*; at a distance of $5\frac{5}{8}$ inches each side of *c d*, draw the projection of the upper fillet; at a distance of $3\frac{3}{4}$ inches draw the projection of the lower fillet; then, with a center located on the line *c d*, describe two semicircles, each of which is tangent to one of the fillet lines just drawn; tangent to each semicircle construct a semi-octagon, from which the

angular lines on the elevation can then be projected; the beads can then be drawn with the bow-pencil.

Now draw the main arches; at a distance of 11$\frac{5}{8}$ inches each side of the center line *c d*, locate the centers *u* and *v* on the springing line *k l*, and draw the curves in accordance with the radii given. From the centers *u* and *v* draw vertical lines as shown; the intersection of these lines with the impost line *m n* will define the centers *w* and *x*; from *x* as a center, with a radius of 6$\frac{3}{4}$ inches, draw a semicircle. Locate the centers *y* and *z* on the springing line *k l*, and from each center, with a radius of 6$\frac{3}{4}$ inches, draw arcs intersecting the center line *v x* and also the circumference of the semicircle previously drawn. From the center *a'*, with a radius of 6$\frac{1}{4}$ inches, draw a circle; the intersections of this circle with the vertical and horizontal lines drawn through its center will define the centers from which the cusps of the quarter-foil can be drawn; mark the width of the ribs and the members composing them, and draw the curves from the centers already determined, and complete the tracery.

Draw the recessed panels, or *niches*, between the shafts; locate the centers of the trefoil arch from the dimensions given, and draw the cusps, and the angle molds around same; draw the small molded gables, the inclination of which is 45° from the horizontal. Draw the angle shafts, with their molded bases and caps, from the dimensions given; the simple curves can be drawn with the bow-pencil, and the compound curves freehand. The sills of the niches have a sloping surface, on which the plinth blocks detail as shown.

Draw the molded cap of the central column on the large pier, of which *a b* is the center line; having drawn the profile from the dimensions given, draw a semi-octagonal plan by the process described for the octagonal impost block, and from this plan project the angular lines.

Locate the center lines of the *foliage* with which the molded string-course above the arches is decorated; draw the outline of one of the stalks; transfer the outline by means of tracing paper, and strengthen the lines.

Observe that there are three kinds of leaf clusters growing

out of the stalks, those over the center lines of the main columns being similar, while the intermediate clusters vary in form. Sketch one of each style, and transfer its outline to the other stalks.

The leaf forms between the stalks are all similar, so that if one of them is sketched in correctly, a tracing can be made and transferred for the others.

Begin on the **diaper**, or surface ornament, in the spandrel on the left of the plate; to obtain the size of the squares, divide the vertical height into 15 equal parts, and make the squares occupied by the ornament equal to 2 of these parts.

Draw the grotesque figure in the spandrel of which *cf* is the center line, and also those adjacent to the apex of the arches. In order to keep the drawing clean and facilitate the process of inking in, the following method of developing the figures and foliage is recommended: Outline the space to be occupied by the subject, whether figure or foliage, on another sheet of paper; sketch in, at first faintly, with the light touch of a soft pencil, strengthening the lines as they assume the correct outline; when satisfactorily drawn, make a tracing and transfer to the drawing plate.

Having completed the figures, draw the *crockets* over the arches.

DRAWING PLATE, TITLE: CLASSIC FAÇADE 1

19. This plate and the one which follows will constitute the **elevation of a classic façade,** suitable for an edifice dedicated to art and science, such as a museum, academy of design, technological institute, or some such establishment that tends to promote the educational interests of society, especially those that partake of an artistic, scientific, and literary character. The façade is composed of two Roman orders, the Ionic and Corinthian, details of which were given on previous plates, so that the student would the more readily realize the value of the parts when assembled in the general design. In order to obtain satisfactory results, the most accurate and careful attention must be given to the location

of the center lines, the determination and drawing of the principal lines that define the divisions of the orders, as well as to the close observance and rendering of the minute details into which these divisions are arranged.

The ability acquired by the student in former examples can be evinced in the mode of executing this façade, and the value of precision, neatness in drawing, and due regard to the little things that the expert draftsman can only expect to realize by studious application, cannot well be better tested than by a comparison of the drawing with the plate.

This plate shows the first story, and is drawn to a scale of $\frac{1}{4}$ inch = 1 foot, but developed by a scale of modules. The second story will be given on the next plate.

The first story being designed in the *Roman-Ionic order*, the student is referred to the drawing plates entitled, Ionic Order and Ionic Details, for the measurements of the subdivisions.

Begin by drawing the center line ab at a distance of $8\frac{1}{2}$ inches from the left-hand border line; draw cd, the top line of the plinth, at a distance of $2\frac{13}{16}$ inches above the lower border line; then draw ef, the upper line of the entablature, at a distance of 26 feet 3 inches by scale above the line cd. As this vertical height defines the altitude of the order, which is equal to $22\frac{1}{2}$ m., the measurement of this module will be 26 feet 3 inches $\div 22\frac{1}{2} = 14$ inches, the unit for the proportional scale, by terms of which the elevation will be developed. Construct this scale by drawing a line $1\frac{1}{4}$ inches above the lower border line, and on it mark a point $5\frac{11}{16}$ feet from the left-hand border line; from this point mark a distance, by scale, equal to 19 m. in length, or 22 feet 2 inches.

Divide this distance into 19 equal portions, defining the modules, and subdivide the first one into 6 equal portions, each being $\frac{5}{30}$ m., or 5 p., which will be the *proportional scale* for the *Ionic order*.

The scale for the *Corinthian order*, which will constitute the second story of the façade, will be explained farther on; observe, however, that all measurements above the line ef

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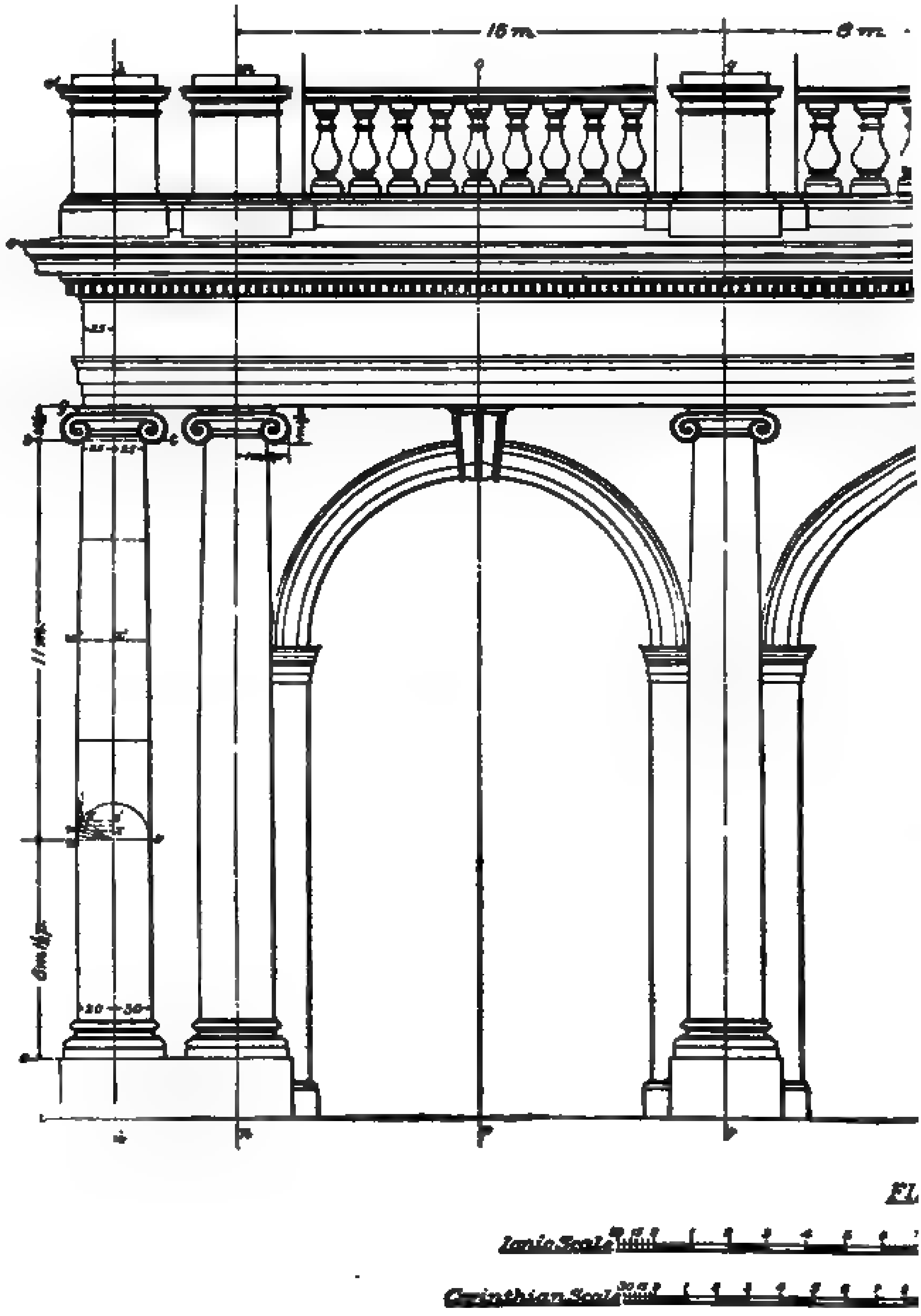
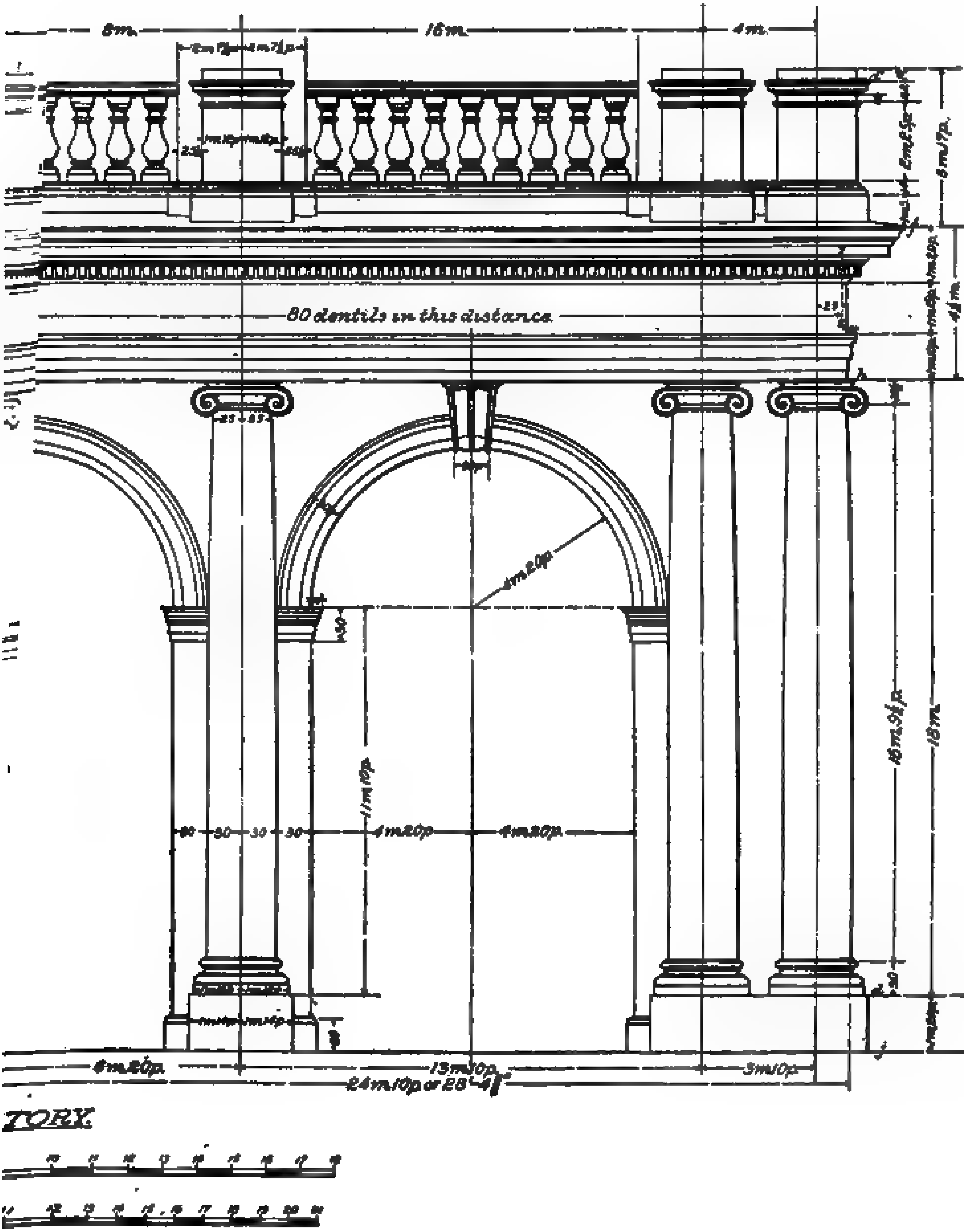


CADE. 1.


80 dentils in this distance
24m.10p or 28'-4⅛"
13m.10p
3m.10p
4m.20p
11m.10p
16m.9½p
18m.
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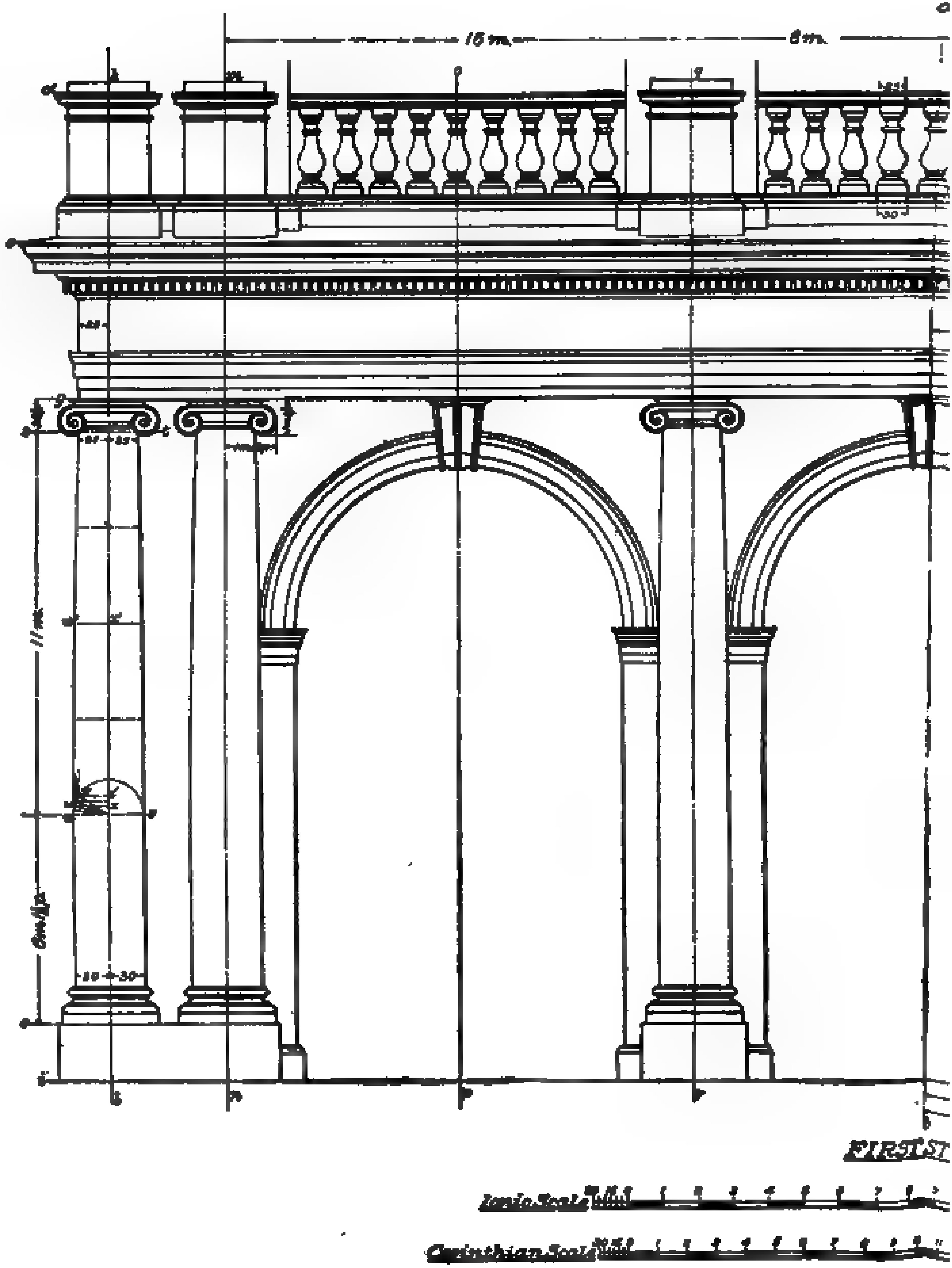
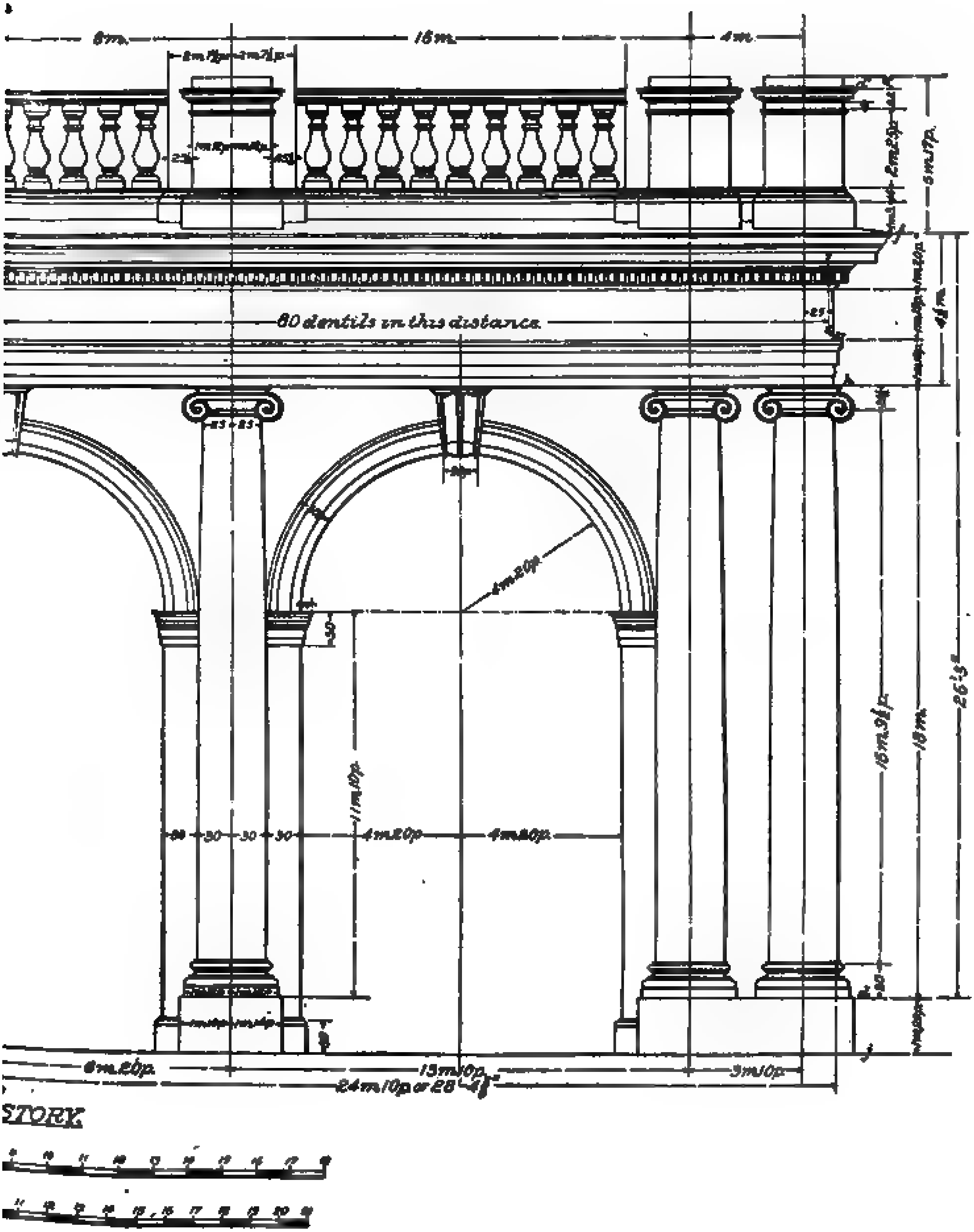
TORY.

CLASSIC I

Scale



FACADE.1.



STORY.

are in accordance with the *Corinthian scale.* The regular scale of ¼ inch = 1 foot should now be laid aside, as the measurements hereafter given will be in terms of the proportional scale just drawn.

At a distance of 4¼ m. below the line *e f*, draw *g h*, the lower line of the entablature; divide the entablature into architrave, frieze, and cornice, as shown, and draw the horizontal lines.

Draw the horizontal line of the base blocks, or plinths, at a distance of 30 p. above the line *c d*, and draw *i j*, the floor line, at a distance of 1 m. and 20 p. below the line *c d*. Draw the vertical lines *k l*, *m n*, *o p*, *q r* parallel to the center line *a b*, and at distances apart equal to the measurements given to the right of the center line *a b*.

As the elevation is symmetrical on each side of the center line *a b*, the left half should be drawn first.

Commencing at the point of intersection of the line *e f* with the vertical center line *k l*, mark a series of points on the line *k l*, defining the vertical subdivisions of the cornice and architrave of the entablature and the capital and base of the column, procuring the measurements from the drawing plate entitled, Ionic Order; through these points draw horizontal lines.

Draw the profile of the base of this column, of which *k l* is the center line; then draw the profile of the entablature.

Draw the volutes of the capital freehand, first locating the projection and lower sides by the measurements given, the details being obtained from the drawing plate entitled, Ionic Details.

Draw the bases, shafts, and capitals of the columns of which *m n* and *q r* are the vertical center lines, and draw the plinth blocks under the bases of the columns.

At a distance of 11 m. 10 p. above the line *c d*, draw the springing line of the arches; then, from the point of intersection of each vertical center line between the columns with the springing line, and with a radius of 4 m. and 20 p., draw the soffit line of each arch.

On the springing line mark a series of points defining the

widths of the members of the *archivolt*, locating them by scale measurements.

Draw these members, and locate and draw the keystones, the sides of which are radial lines; these keystones are capped with an abacus and worked like a console or bracket on the face, as they are in this position designed to give support to the entablature.

From the intersections of the soffit lines with the springing line, project the vertical pier lines. Mark the width of the impost blocks, which is 30 p., and divide them by scale measurements into facias and cap members, and profile them as shown, and draw the bases of the piers.

In order to draw the dentils of the bed mold of the cornice, first locate the dentil adjacent to, and also the one which projects beyond, the return line of the frieze; this should be done by reference to the drawing plate entitled, Ionic Details, which gives the accurate measurements. Draw *y z*, the center line of the second dentil from the return; divide the horizontal distance between the line *y z* and the center line *a b* into 80 equal portions; each division will be the center line of a dentil. To facilitate this process, the horizontal distance can be divided into 4 equal portions and one of these divisions subdivided into 20 parts, which can then be transferred to each primary division; as each dentil is 6 p. wide, one-half of this width, or 3 p., can be laid off on each side of the center lines by means of the dividers and the lines drawn.

By calculation it will be found that the groove between the dentils is very slightly in excess of that shown on the drawing plate entitled, Ionic Details, but this cannot be obviated in order to have the divisions close correctly. This difference, however, in practice, is indiscernible, as it is only .025 p., or about $\frac{1}{50}$ inch.

Having completed that portion of the elevation to the left of the center line *a b*, proceed with the development of the right-hand portion; this should be done before the balustrade over the cornice is drawn, as that portion of the elevation above the line *e f* properly belongs to the second or

superimposed order, and the measurements thereon given are in accordance with the scale of that order. As the superimposed order is the Corinthian, and is also developed by a scale of modules, it will first be necessary to draw this scale. The lower diameter of the column which rests on the pedestal is the same as the upper diameter of the Ionic column on the first story; therefore, the module, or semi-diameter, of the Corinthian column will be equal to 25 p. of the lower order. Construct this scale, drawing the lower line $\frac{11}{16}$ inch above the lower border line; draw the zero line, or the line marked *0*, immediately under that of the Ionic scale, and, as 10 modules on the Ionic scale will be equal to 12 on the Corinthian, project the division marked *10* on the Ionic scale down to the Corinthian scale, and mark it *12*; then divide the distance from *0* to *12* into 12 equal parts and complete the scale, as shown.

On the line $q\,r$, mark a series of points, defining the vertical divisions of the pedestal, and draw horizontal lines; the cornice and base lines of the pedestal also form those of the balustrade, which draw.

Draw the pedestal and pier lines to the left of the center line $a\,b$. In order to locate the center line of the balusters, which are each 1 m. wide at the base, mark a point on each pier 15 p. from the edge, and divide the distance between these points into 10 equal portions; the division lines will give the desired center lines for the balusters.

On the center line $a\,b$, which passes through the center baluster, mark a series of points defining the vertical divisions, and draw the lines; then profile the baluster.

The swell of the body can be drawn by means of the bow-pencil; the other members should be drawn freehand. Observe that the upper block of the baluster is 25 p. wide, while the lower block is 30 p. wide. Draw in all the balusters to the left of the center line $a\,b$; then draw the pedestals, piers, and balustrade to the right of the center line; indicate the position of the line $c'\,d'$ by a dotted line at each side of the façade, and complete the drawing.

DRAWING PLATE, TITLE: CLASSIC FAÇADE 2

20. This plate shows the elevation of the **second story of the classic façade,** and is developed by means of the *proportional scale* for the *Corinthian order* on the previous plate. This story is designed in the *Roman-Corinthian order*, the details of which may be obtained from drawing plates entitled, Corinthian Order and Corinthian Details, to which the student is referred for the measurements of the subdivisions of the order.

Begin by drawing the center line $a\,b$ at a distance of $8\frac{1}{4}$ inches from the left-hand border line; draw $c'\,d'$, the top line of the cornice of the pedestal (as shown on the previous plate), at a distance of $2\frac{1}{16}$ inches above the lower border line.

Transfer the position of the center lines of the columns from the previous plate by means of a strip of paper, locating the points on the edge of it by means of a needle, and puncture these points on the new plate, taking care that the center line exactly coincides, as upon this operation the accuracy of the work will depend, and as the plates may be united, as hereinafter explained, the slightest discrepancy will be observable. The façade being symmetrical, the left half of it should be drawn and completed before the other half is begun.

Draw the center lines of the columns and arches in accordance with the measurements given; draw $e\,f$, the lower line of the entablature, at a distance of 20 m. above $c'\,d'$, and draw $g\,h$, the upper line of the entablature, at a distance of 5 m. above $e\,f$. From $e\,f$ lay off a series of measurements defining the widths of the architrave, frieze, and cornice, and draw the lines; from the drawing plate entitled, Corinthian Details, procure the measurements of the subdivisions of these members, mark the points carefully, and draw the horizontal lines.

In locating the center lines of the modillions, observe that they should coincide with the center lines of the columns and arches over which they occur; the modillions are set at 40 p.

between centers, and their widths should be marked by means of the dividers. Having drawn the modillions, locate the center lines for, and draw, the dentils, observing that there is a dentil immediately under each modillion; as the dentils are set at 10 p. between centers, the space between the center lines of the modillions should be divided into four equal portions, which will give the center line of each dentil. Draw the return of the entablature, making the various projections equal to the measurements given.

Sketch in the profile of the lion's head on the return, and also the blocks, defining the position of each head on the crown mold of the cornice, the centers being immediately over the modillions.

Lay off the measurements for the base, shaft, and capital of one of the columns, and profile them as shown. The entasis of the shaft should be drawn by the method given for profiling the shafts on drawing plate entitled, Corinthian Order.

The foliage of the capitals is drawn in block form, after the manner followed in drawing plate entitled, Composite Order. Draw one of the capitals, and transfer the leafwork, by means of a piece of tracing paper, to the others.

Draw the springing line of the arches, which is 12 m. and $22\frac{1}{2}$ p. above $c'\,d'$, and from the points of intersection of this line with the center lines of the arches, with a radius of 5 m. and $22\frac{1}{2}$ p., draw the soffit line of the arches; on the springing line, lay off the widths of the molded members of the archivolt, and describe them from the same center.

Draw and profile the impost blocks of the piers on which the archivolts rest, and draw the keystones, which also serve as supports for the architrave.

From the line $g\,h$, mark a series of points on the center line $a\,b$ defining the heights of the members composing the pedestals of the balustrade; viz., 30 p. to the top line of the plinth, 13 p. for the base mold, 2 m. and 18 p. for the height of the dado, 13 p. for the cornice of the pedestal, and 12 p. for the blocking course and the **wash,** or inclined surface of the cornice. Through the points marked, draw horizontal

lines; subdivide the cornice and base members of the pedestal into molded parts, as shown, by scale measurements. Draw the vertical lines which denote the width of each pedestal and check-block of the balustrade, and profile the molded returns of the bases and cornices.

Locate and draw the center lines of the balusters, by the method given for those in the previous plate; divide the height of the baluster on the center line *a b*, by scale measurements, as shown, and profile its outline; the swell of the body may be drawn by means of the bow-pencil; the other members should be drawn freehand; when satisfactorily drawn, project the horizontal lines faintly across each panel and complete the balusters.

In order to draw the emblematic statues of Art and Science, first draw the center line, and mark the height of the figure by scale measurement; divide the height into 8 equal parts, and draw horizontal lines; one of these parts will give the height of the head.

On each side of the center line of the figure, draw vertical lines at intervals equal to those between the horizontal lines, thus forming a diagram of squares. Draw a center line through the figure on the plate, and divide its height into 8 equal parts as above; draw horizontal lines, and form a series of squares, as was done on the drawing; then observe where the governing lines of the figure on the plate intersect with the lines forming the squares; mark the relative positions of the intersections on the lines forming the squares on the drawing; then sketch in the outlines freehand.

Draw the vases which crown the angle pedestals in accordance with the figured dimensions, and complete the drawing.

As the width of the facade and the height of the orders were drawn to a scale of $\frac{1}{4}$ inch = 1 foot, even though the design has been developed by a scale of modules, still the dimensions of each and every part will have a relative value by the former scale which can readily be expressed in feet and inches, thus reducing it to a working drawing.

Thus, a measurement of 10 m. and 15 p. on the Ionic scale, the module of which is equal to 14 inches, will give

$10\frac{15}{16}$ m., or 12 feet 8 inches; and as 10 m. on the Ionic scale equal 12 on the Corinthian scale (from the fact that 25 parts of the Ionic scale was adopted as the module of the Corinthian scale), $11\frac{5}{8}$ inches is the value of each module of the Corinthian scale.

After the student has had his drawing corrected and returned to him, he may, if he so desires, mount the last two plates together, as one plate. If this is done, the last plate should be cut on the line *c′d′* and carefully attached at its proper level to the plate previously drawn, by a thin film of paste, which is preferable to gum, as it does not stain or discolor the paper.

INDEX

NOTE.—All items in this index refer first to the section (see Preface) and then to the page of the section. Thus, "Cornice 16 2" means that Cornice will be found on page 16 of section 2.